REPORT RESUMES

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VISION SCREENING OF THE PRESCHOOL CHILD, REPORT OF A STUDY.
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USING A SAMPLE OF 94 CHILDREN (31 TO 54 MONTHS OLD), THIS STUDY COMPARED EIGHT VISION SCREENING PROCEDURES FOR YOUNG CHILDREN IN THE ABILITY TO TEST FOR SEVERAL VISUAL FUNCTIONS, AND PREFERENCE AMONG THEM BY CHILDREN. THE SUBJECTS WERE ORIGINALLY TESTED USING THE EIGHT SCREENING TESTS, AND 6 MONTHS LATER 40 OF THE CHILDREN WERE RETESTED FOR CHANGES IN VISUAL ACUITY AND EYE DOMINANCE DURING THE INTERIM PERIOD. RESULTS INDICATED THAT THE RELATIVE SCREENING ABILITY OF THE PROCEDURES WAS UNDETERMINED FOR THE VISUAL FUNCTIONS OF VISUAL ACUITY, MUSCLE BALANCE, AND COLOR PREFERENCE, DUE TO NONTESTABILITY OF SIGNIFICANT NUMBERS OF THE SUBJECTS. THE RESULTS INDICATED THAT EYE DOMINANCE COULD BE ESTABLISHED. THE CONCLUSION SUGGESTS THAT PRESCHOOL CHILDREN 30 MONTHS OF AGE AND OVER CAN BE SCREENED, ALTHOUGH 50 PERCENT MAY BE NONSTABLE. THIS DOCUMENT IS AVAILABLE FROM THE SUPERINTENDENT OF DOCUMENTS, U.S. GOVERNMENT PRINTING OFFICE, WASHINGTON, D.C. 20402, FOR $0.45. (KH)

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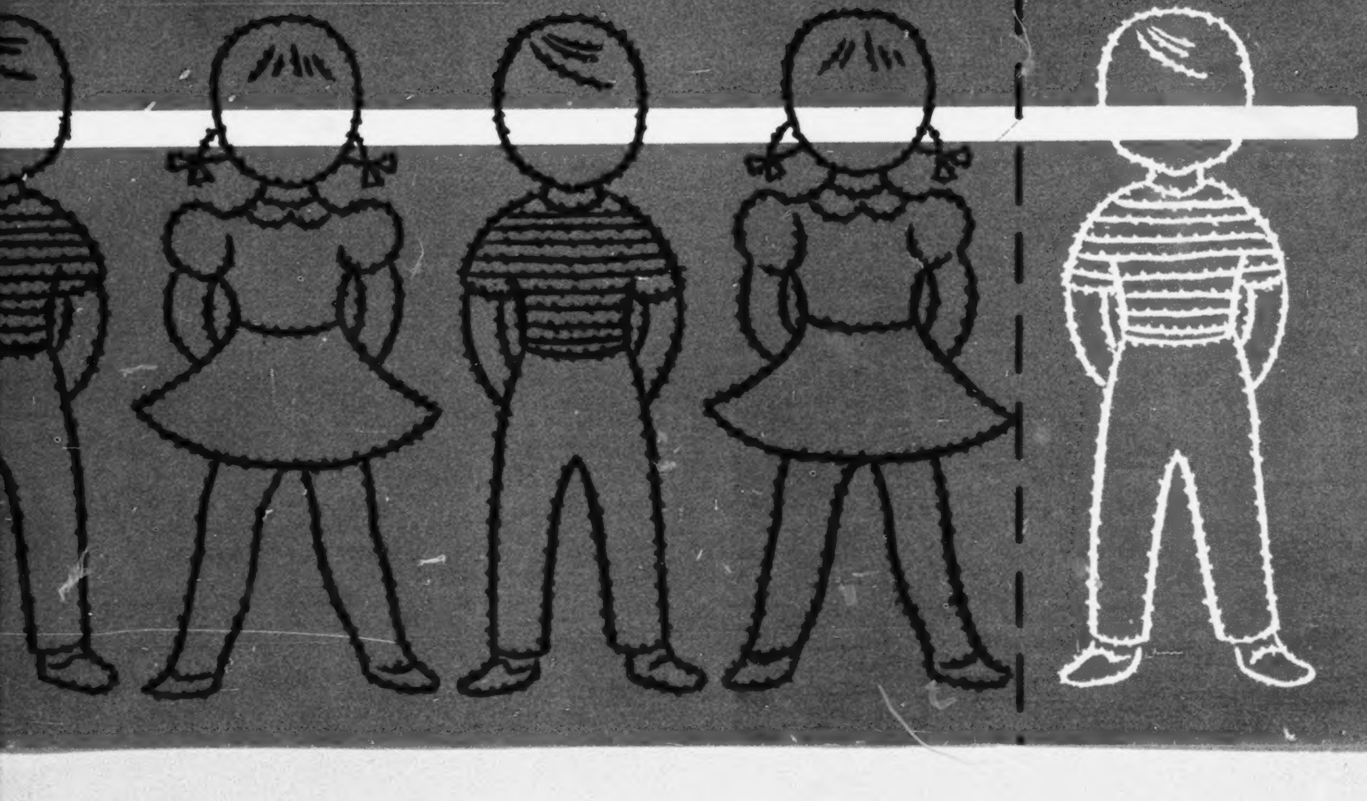

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vision screening of the preschool child

REPORT OF A STUDY

ERRATA

Page 6.	Picture caption should read "Allen Picture Cards."
Page 7.	Picture caption should read "Osterberg Chart."
Page 15.	Line 10, right column, should read "project at 962 Parker Street."

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I. INTRODUCTION

This study was undertaken after an extensive review of the available literature on preschool vision. This is a body of literature which is often vague and inconsistent and leaves many questions unanswered. The present study is descriptive and limited to a small number of subjects. In order to define the present work within the literature and within the total subject of preschool vision screening, some basic questions are posed and discussed below.

What are the vision problems of preschool children?

The vision problem of the preschool child which has been the major impetus to the development of screening procedures is amblyopia ex anopsia (unilateral amblyopia of disuse, "lazy eye blindness"). This is considered a problem which cannot await later detection and treatment. Refractive errors and heterophorias in this age group have not been well-defined and generally screening programs have only aimed indirectly at detection of these problems by detecting their consequences like low vision.[1-9]

Even less well-defined are general developmental problems involving vision—problems which might bear some direct relationship to later difficulty, physical and educational. There is growing interest in normal visual development and the consequences of deviations from this normal. The Gesell Institute of Child Development has given considerable attention to this subject, and work in this area is being pursued by some optometrists, educators, and psychologists.[10-12] Medical and public health practitioners have not yet directed particular attention to this area in an organized way.

What are the vision tests available for preschool children which might be adapted for screening purposes?

Most of the vision tests recommended for children aged 5 years and younger are tests of distant visual acuity. These tests detect low vision, and the child is then given a professional examination to determine diagnosis and treatment.

Vision tests available for infants are based upon the elicitation of reflexes which, by their presence, indicate that visual pathways are intact.[13-18] The newborn is not blind if he demonstrates either ***pupillary reaction*** to light, the constriction of the pupil when light is shown into either eye, or ***vestibular reaction,*** the slow following of the eyes in the direction the infant is turned. The visual acuity of the newborn has been estimated by production of ***opticokinetic nystagmus,*** the response to seeing a moving series of lines. After 1 month, the presence of vision may be demonstrated by ***optically elicited movement,*** the movement of the eyes toward a peripherally appearing object. Experimentally, devices based on this reflex and using graded stimuli have been used to measure the vision present. These objective vision tests, however, seem to underestimate vision when the results are compared to subjective tests.

Visual acuity of the child from 10 months to 2 years has been estimated with various subjective tests such as *Worth's marble balls* [19, 20] and *Bock's Candy Bead Test.*[21-24] Ambulatory infants and toddlers are expected to retrieve small, standard-sized objects from varying distance using each eye in turn.

Communicative preschool children are usually requested to give a subjective response, to indicate in some way that the test object is perceived. In picture tests, the child names or shows a similar picture or object to the examiners [25-36]. In direction tests, the child names or indicates with his hand the direction of the test object [37-40]. Several types of visual acuity tests were included in this study, and these will be described in detail in Section II.

Tests of eye muscle balance are those used for adults; [41-43] techniques of administration and superficial apparatus changes make these tests more suitable for children.

Vision test batteries for preschool children have been established to detect abnormalities of vision as they relate to general development.[12] Several of these functionally oriented tests, e.g. tests of performance and eye dominance, were included in this study and again will be described later.

Whatever vision tests are suitable for screening must be fairly nontechnical. Subjective vision tests, however, are also part of the professional examination; they cannot be replaced by the cycloplegic examination which does not serve the same purpose of indicating what use the child is making of his eyes.

Have the available vision tests been used for testing large numbers of children and adapted for screening purposes?

Several of the visual acuity tests, e.g. "Stycar", Allen pictures,[25-27] and Osterberg chart,[28] have been used over a period of years for testing many children. The Snellen E test [38-40] is the only test so far which has been standardized for use by nonprofessional personnel as a screening tool.[44] Most acuity tests have never been used in controlled settings by impartial observers.

Other vision tests are administered to large groups of children, but not necessarily in the context of an easily reproduced screening program. For instance, British orthoptists give routine cover tests to children entering school; [45] there are not enough professional orthoptists in this country to establish a similar program.

The functional vision tests [10, 12] have been given to many children as individuals on an experimental basis. These have not been adapted for screening.

How reliable are these tests when administered at different times, by different personnel, in different places?

Carefully controlled studies of the reliability of the available preschool vision tests have not been done. The reliability of school vision tests has been investigated more thoroughly,[46] but this information cannot be generalized.

In most screening programs a certain lack of reproducibility is expected and children are retested under new circumstances before referrals are made.

How valid are the results of the screening tests when compared to professional findings on the same child?

Any screening test should bear some definite relationship to a more refined procedure from which it is derived. The referrals from vision screening tests should, for the most part, be those children whom professional eye doctors would select for specialized treatment if they had examined all the children screened. This is a particular problem in vision testing where the number of concerned professions and the variation within each profession make the definition of a correct referral very difficult. This variation in standards of referral was clearly demonstrated in the study by Lancaster *et al.*[47] Variation in the findings of even a single professional examiner is demonstrated by Sloane.[48] In the extreme situation, one person might be considered a needless referral by one professional consultant, and a correct referral by another. When standards are set arbitrarily for the purposes of a screening program, the validity of the screening procedures can be determined. This determination has not been made completely for a large population of preschool children. In general, clinical follow-up of referrals has been inadequate, and the number of under-referrals has not been determined.

What is the expenditure of time and money involved in screening preschool children?

There is no definite answer to this question to be found in the literature. Only when there is agreement about screening procedures, can the expense incurred by such programs be determined. Then, screening expenditure will have to be justified by proven vision conservation. This will be the subject of further investigation.

At what age are preschool vision tests applicable?

The vast majority of authors state that age 3 years is the optimal time to screen for amblyopia. One reason offered is that 3 years is when retinal reflexes are established and that disuse at this age frequently precedes unilateral amblyopia.[49] Another pragmatic reason to test at age 3 is because subjective tests first become possible at this time. However, the most frequently employed, and the best standardized "preschool test", the illiterate E, is frequently not successful before age 4 years.[50]

Variations on the E continue to appear as "new tests", but the basic principle, a subjective response to direction, is unchanged and young 3-year-olds are still nontestable. The Snellen E is an excellent acuity test for an older child or illiterate adult, but may be too abstract for the young child. Pictures of toy animals, on the other hand, are not too interesting to adults and are very appealing to preschool children.

Age-appropriateness of vision tests warrants some attention. If age is considered an important factor in prognosis, then perhaps children 3 years old and even younger should be screened; this would necessitate the development and standardization of some testing method for this age group. If children 4 years old can be as successfully treated as younger children, then there is no need to develop new methods for testing visual acuity. Since there seems to be general agreement that prognosis is related to age and children should be tested as young as possible, the subjects chosen for this study were around 3 years old.

The aims of the present study were:

(1) To test several visual functions with available procedures.

(2) To clarify the abilities and preferences of young preschool children with respect to these procedures.

(3) To detect vision problems in the population studied.

II. MATERIALS AND METHODS:

background and description

Tests

Visual acuity—"Stycar"

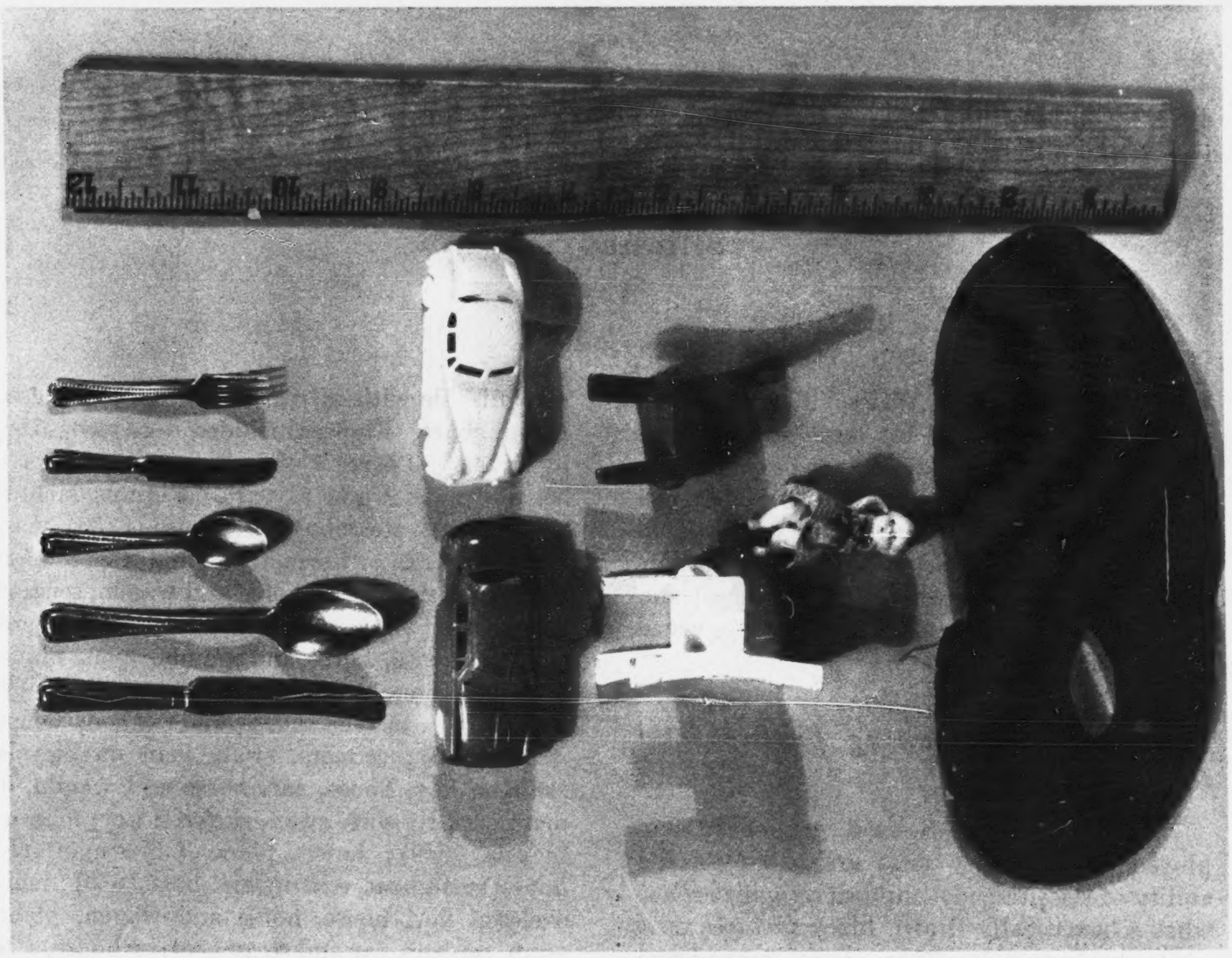
Screening Tests for Young Children and Retardates or "Stycar" [29-32] is a set of acuity tests designed by Sheridan (a medical officer) and Pugmire (an ophthalmologist), which are not well known in this country, but have been used successfully in Britain for almost 25 years. These tests were designed, unlike previous tests, with facts of normal child development in mind. In addition to high validity for visual acuity, they were to provide information about the child's meaningful visual abilities, those involved in comprehending the environment. The tests were to be applied to young children or handicapped children including the partially sighted, deaf, cerebral palsied and mentally handicapped.

Matching letter test. For the older preschool child (3 years on), a ***letter test*** is used; the child matches the letter shown to him with the same letter on a key card he holds in his lap or reproduces the letter seen by drawing it. In this study, children were sometimes asked to cover the letters with pennies instead of pointing; this technique was used in a Lotto acuity test in France,[33] which is basically like the Stycar letter test. Single letters are presented to 3–5 year olds; a letter chart is used for children more than 5 years old. The youngest group, about 36–48 months, match 5 letters (O, X, V, T, H), presumably easily recognized because of shapes that can be drawn and are frequently used in mass media. When five letters are used, there are five possible responses, or four if V and X are confused; thus the same number of choices is available as with the E when direction sense is well developed. Older children 5–9 years match seven letters (A and U added) or nine letters (C and L added).

Near letter test. A near vision test (12–14 inches) is included for those children who may have defects at near but test normally on distant tests, and for those whose maturity is not great enough to conduct a test at any distance. Acuity is graded from N36 to N6, about equivalent to type sizes 36 point to 6 point.

Distant letter test. This test is administered at 20 feet; with the younger child the distance is established without loss of contact by testing in a mirror placed 10 feet away, permitting examiner to sit with the child. Acuity is graded from 6/36 to 6/4.

Miniature toy test. The Miniature Toy Test is used for children between 20 and 36 months. The child receives a set of 10 toys consisting of familiar objects and is asked to name them if he can; these include a car (2-inch, colored plastic), plane (2-inch, metal), doll (2-inch, plastic with colored cotton dress), chair



MINIATURE TOYS AND MASK OCCLUDER

(2 x 1 inch, colored wood), knife (3½-inch, metal), fork (3½-inch, prongs 8/10 inch, metal), spoon (3½-inch, bowl 1 x ¾ inch, metal), small knife (2¼-inch, metal), smaller fork (2¼-inch, 4 prongs 1/16 inch apart, metal), smaller spoon 2¼ inch, ¾ x ½ inch bowl, metal).*

He then must match or name his toys to duplicates shown him by the examiner on a dull black background 10 feet away. This is done first with both eyes, then with each eye. There is no numerical Snellen equivalent determined for this test. It is, rather, a comparison of the two eyes. The best acuity detectable is the ability to distinguish the small fork from the small spoon, and this is said to approximate 6/6. A comparable near test for these young children is their ability to detect small threads and toys close at hand (about 20 inches).

In this study, black cloth Hallowe'en masks were used as occluders. An eye on each was covered with adhesive tape and black paper to serve as an occluder for one eye while the other peeked through a 1 x 1½-inch hole. There was no consistent occlusion of one eye first, but the order of occlusion was noted.

The Stycar Vision Test is distributed by the National Foundation for Educational Re-

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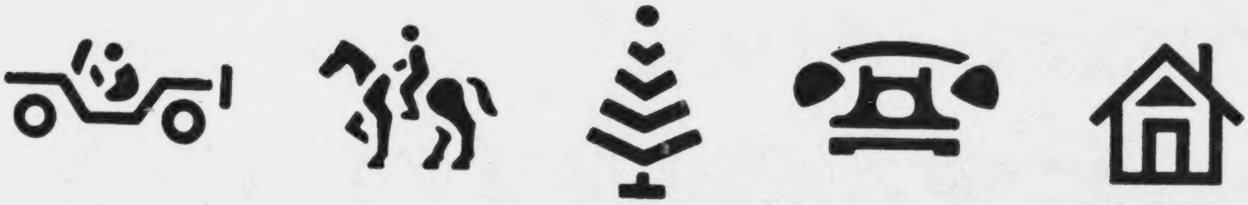
*These measurements are based on the set of toys used in this study, and differ slightly from those stated in the test manual.



OSTERBERG CHART

search in England and Wales. The tests were *not* originally designed for large scale routine screening, but rather they were to be given by a medical examiner or psychologist.* They can and have been easily given by nonprofessional personnel, but in such situations the authors advise over-referring (any doubtful cases) and frequent checks on the testers by the concerned medical officer.

Visual acuity—Naming pictures and toys

Picture tests. Several commonly employed visual acuity tests are based on the ability of the preschool child to recognize somewhat schematically drawn black pictures on a white background. These tests depend for their success upon the child's verbal ability; recognition is indicated by an appropriate and consistently used name. Many pictures are things one might not expect a child to recognize because of lack of experience with similar things; others seem to be poor reproductions of the actual object.

In this study, the children were asked to identify pictures in three different picture series, usually only at reading distance and with both eyes open: The ***Osterberg chart*** [28] (4th and 5th editions made by Nyrop and Maag, Copenhagen, Denmark) consists of pictures inspired by children's drawings, drawn in black on a white background to subtend a visual angle of one minute at appropriate distance, and found recognizable with increasing distance, are used for his chart. Figures included were recognized by at least 80 percent of Danish children tested between ages 2 and 5 years. Figures include swan (6/60), steamboat and house (6/36), man, car, and horse, or horse, train, and skeleton key (6/24); skeleton key, horse and wagon, scissors and boat or swan, steamboat, horse and wagon (6/18); house, horse and wagon, man, plane, Christmas tree, man on bicycle—or man on bicycle, Christmas tree, horse and wagon, house, man (6/12); scissors, swan, man on bicycle, skeleton key, house, car, horse and wagon, or man, cup, scissors, swan, skeleton key, man on bicycle (6/9); horse, plane, Christmas tree, house, steamboat, scissors and boat (6/6); man, skeleton key, house, horse and wagon, plane, swan, scissors, car and steamboat, or house, scissors, cup, Christmas tree, horse and wagon, skeleton key and man (6/4). The Standard Wall Chart was shown and also a photographic reduction (1 x 1½-inches) of this chart. This small chart, obtained from Dr. Trygve Gundersen, is a near vision test; the figures are comparable in size to the standard Jaegar types.

The ***Allen picture cards*** [25] are original drawings borrowed from Massachusetts Eye & Ear Infirmary Ocular Motility Clinic. These are bound in a booklet, unlike the single cards of the commercially produced test, but could be presented singly. Pictures included were: teddy bear, plant, flower, clown, birthday cake, Xmas tree, steamboat, telephone, and horse with rider. The test now is available from Ophthalmix, LaGrange, Ill.; it includes a car, and the plant, flower, and clown have been omitted. Cards measure 4 x 4 inches and pictures are within an area of 1 square inch, approximately

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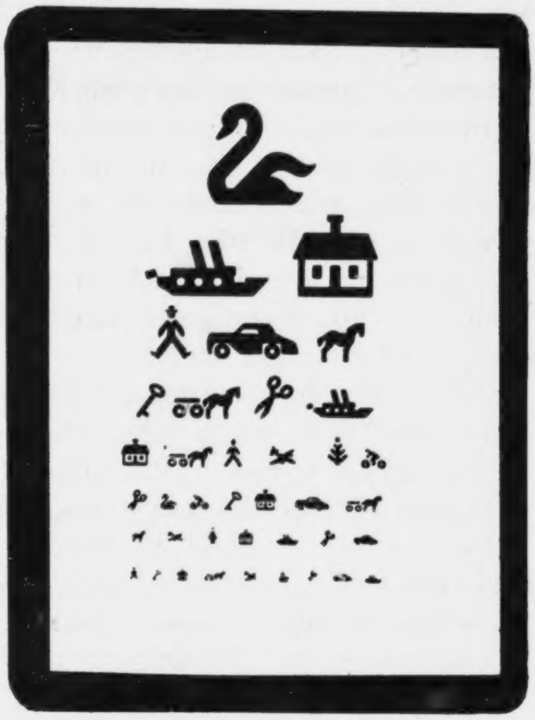
*The test kit was obtained through Dr. Lenin Baler of the Harvard School of Public Health, who provided supervision in the use of "Stycar" materials.



ALLEN PICTURE CARDS

the size which subtends a 1-minute arc when viewed at 30 feet.

The ***American Optical Kindergarten Chart (1946)*** consists of pictures which include a sailboat (20/200); circle and cross (20/100); flag, star, and heart (20/70); heart, cross, and sailboat (20/50); star, moon, circle, and flag (20/40); circle, hand, star, cup, cross (20/30); star, cross, circle, heart, flag (20/20); and moon, heart, cup, star, and cross (20/10).

Toys. Children were also asked to name some three dimensional toys, from a dime store, which were representations of the same objects as those in the picture tests, e.g. house, tree, horse, telephone, teddy bear, scissors, man. The purpose of this was to see if recognition could be enhanced by a more realistic representation than that in the picture. Recognition could be indicated verbally or by pantomime play with the toys. This test was included to to see if verbal ability might be significantly improved by this change from picture to toy targets, and if those children who did not respond verbally might indicate recognition by play.

Visual acuity—Indicating directions

The most widely used preschool vision tests depend upon the child's perception and imitation of direction as a response; if the child responds correctly, it is assumed that he not only saw the stimulus, but he interpreted it as well. With such tests, if the response is incorrect, it is not known if the child failed to see the stimulus or failed to interpret or communicate what he did actually see. There has been much work in child development and psychology [51-64] based upon conceptualization of the directionality of figures. The findings in this work point to a tenuous grasp of the direction concept in the preschool child. It is common even for first graders in school to demonstrate some right-left confusion as evidenced by frequent reversals, e.g. letters or words like "b" and "d", "was" and "saw". Young children who have difficulty recognizing abstract forms might appear more visually acute when familiar concrete forms are used.

In contradistinction to these findings of psychologists and educators, the direction-based tests have remained the tests of choice for preschool children. The Snellen E test has been standardized and is used frequently by the National Society for the Prevention of Blindness.[44-50] Perhaps because mainly older preschool children, 4 and 5 years old, have been included in these studies, and probably because of a concretization of the E figure into a table, these programs have met with some success.

Drawing. Children were asked to copy lines, geometric forms and letters after demonstrations were drawn in front of them. This was done on a pad of paper with crayons. The hand used and manner of holding the crayon were noted. Lines were vertical, horizontal, two obliques, a cross. Forms were a circle, triangle, diamond, and square. Letters were an E (in one or more directions), C, U, and D.

Hand and "E". An attempt was made to teach the Sjogren hand [39] and the Snellen E,[40] in order to elucidate the learning procedure involved and the comprehension attained. A 20/40 size hand card, and then a 20/20 E card were shown at conversation distance, and the child was asked to match his hand to it as it appeared in different directions. Usually no attempt was made to test actual acuity by doing this at 20 feet and occluding each eye; children who learned successfully were asked to repeat the test after stepping back a few paces. The E card was also matched by a cutout E figure (3 x 3 inches) made of white cardboard, and held by the child. Notations were made of the way the child responded and the duration and amount of interest was estimated.

Visual acuity—Eliciting opticokinetic nystagmus (OKN)

Opticokinetic nystagmus (OKN) is a nystagmus which can be used to objectively measure visual acuity; it is produced when a simple repetitive moving pattern is seen by the eyes.[66] The stimulus is usually vertical lines (stripes) moving horizontally; the eyes follow a line (slow phase), then jerk back to fixate a succeeding line (rapid phase). Also known as "train nystagmus", this is the response of the eyes to multiple passing telephone poles. Vertical opticokinetic nystagmus, the response to a horizontal pattern moving vertically, is more difficult to elicit. This nystagmus differs from vestibular nystagmus in that it continues as long as the eliciting stimulus is present. The eye must see the stimulus in order for the nystagmus to be produced, and if one eye perceives the stimulus, both eyes will show the nystagmus. The stimulus must be presented to one eye at a time or to a visual field not shared by the two eyes in order to be sure that each eye sees. As the basis of a test of visual acuity,[67] more acuity vision is measured when lines and spaces are narrower and the distance from the subject is greater. A technique to produce nystagmus has been used to test newborn infants for blindness and to determine how well normal newborns see.[14] A more refined test has been used for adult acuity testing, but its use has been limited to detection of malingerers and hysterical blindness; subjective tests are more accurate than this when subjects are cooperative.[67] Precise measurements of nystagmus with recording electrodes for the extraocular muscles has been used as a test of ocular dominance.[68]

There is at present no workable objective measure of visual acuity for preschool children. Such a test might answer some of the problems of administration and cooperation with these young subjects. Possibilities for an opticokinetic nystagmus test with preschool children have never been fully investigated, and this will be the subject of a further study.

In this study the nystagmus is elicited by pulling a striped tape, e.g. a tape measure, in front of the subject's eyes. This simple technique was used because the purpose of including this test was only to see if children this age would be interested and respond with nystagmus; there was no effort made at that time to actually measure acuity. No attempt was made to occlude one eye during the test. A 5-foot tape measure, white plastic ribbon with markings in black separated by 1/16 inch, was used. The child was instructed to look at the examiner; the rolled tape was then held at eye level off to the left side of the child's face and the end drawn across in front of the eyes from left to right. This was done quickly and frequently with much verbalization, "Look at it, look at it, etc." The reverse side of the tape with a light green background was presented to some children as well. Notation was made of the parallelism of response between the eyes and any difference in response between the two directions in which the stimulus was presented.

Muscle balance

Tests of extraocular muscle coordination between the eyes themselves and the eyes and hands were included in an attempt to detect external pathology, latent strabismus, nystagmus, immature eye-hand coordination, and subclinical cerebral palsy.

Nearpoint of convergence and penlight following. Following a penlight as it moves out to and in from the peripheral visual fields gave an indication of child's attention as well as an opportunity to find field defects. Nearpoint of convergence (N.P.C.) was determined with the light, and the distance and deviating eye at the near point were recorded. Touching the light at several distances and threading it with the rings of the toy scissors gave an indication of hand coordination, and behavior on these tests could be compared to expected behavior based on many such examinations by Apell and Lowry.[12]

A Hirshberg test or "corneal reflection" test, the observation of the relative positions of the corneal reflections was done incidentally during observation of the extraocular movements. Relative eccentricity of one reflection indicates a possible deviation of that eye. This test was not systematically used as an absolute indication of muscle imbalance because of the view that disparity between the position of corneal reflections may frequently be a normal finding. Any positive finding, however, was considered when recommending followup for a particular child.

Cover test. A cover test, the most frequently used and criticized test for eye muscle balance, was attempted. The examiner's hand was used as an occluder and the lighted penlight, 12 inches away, was the focus. A rough distance cover test was done without a standardized target; the child was directed to look at some small object outside the window approximately 20 feet away.

Red glass test. The red glass test for diplopia was attempted. A 2 x 2 inch red plastic square was placed before each eye in turn; the penlight held about 16 inches away was the target. The child was asked how many lights he saw and what color they were. "One red light" indicates fusion of images is occurring; "two lights", one white and one red, indicates some degree of muscular imbalance is present.

Stereoscope. A hand stereoscope equipped with three cards was used to determine reactions to such an instrument and detect failure of fusion. The cards used were:

Bird and cage (colored, Kroll A1).

Pumpkin with one eye on each side (Hale O2).

Jumping dog and lion holding a hoop (Kroll A3).

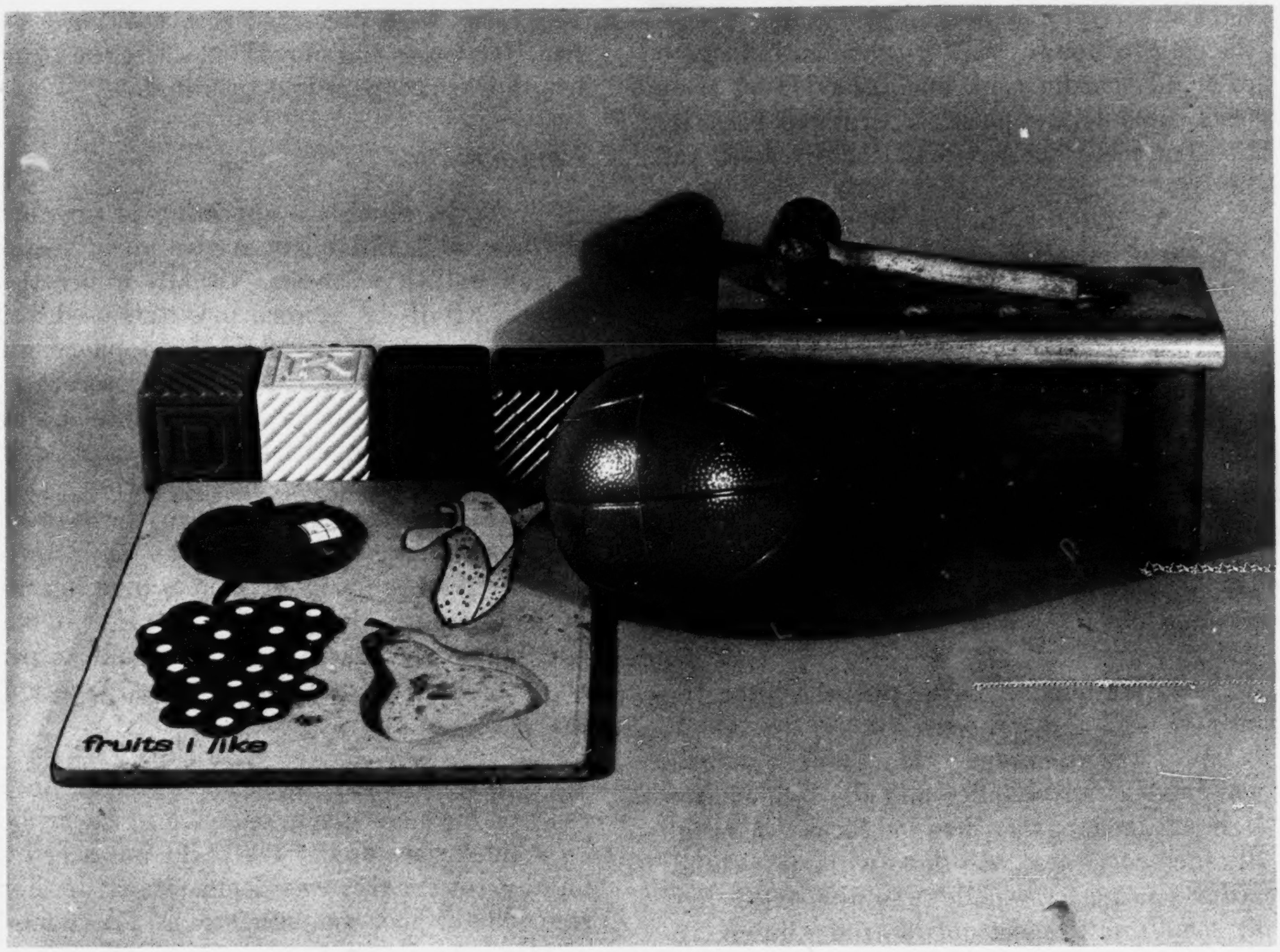
The cards were presented at a position 5 cm. from the lenses and moved out along the 15 cm. length when cooperation permitted.

Performance

Tasks which are appealing to preschool children as familiar games give an indication of how well they function visually in practical terms. All of the performance tests used were similar to tests in the child development and optometric literature,[10-12] but none was exactly the same. The tasks were comparable and the tools, if anything, easier than those used by Gesell. It is behavior in approaching these tasks which assumes comparable patterns rather than performance on the tasks themselves. This behavior comparison permits an estimation of maturity of the children tested. It was anticipated that these children would be performance oriented and might respond favorably to this type of task.

Blocks. Six colored plastic cubes (three red, one blue, one green, one yellow, 2½ inches on a side) were used. The child was asked to build a tower; this was demonstrated if there seemed to be poor comprehension. The number of blocks piled, the hand used to pile, and the stance of the child were noted. A bridge of three blocks was demonstrated and, with the demonstration intact, the child was asked to reproduce this with the other three blocks. A train (five horizontal blocks, and an engine) was demonstrated, and after the blocks were knocked askew, the child was asked to build such a train.

Peg bench. A commercial toy designed for 2 years and older, was purchased to serve as a test requiring coordinated aim, judgment of depth and awareness of a third dimension. The toy is composed of a red and neutral colored bench measuring 10 x 4 x 5 inches, 12 colored pegs (2 each of red, blue, purple, yellow, orange, and green) cylinders measuring 1⅜ inches long and ⅝ inches diameter, and a hammer with 5-inch handle ½ inch diameter, and a head 2¾ x 1½ inches deep. Six of the pegs sit in ½ inch deep holes on top of the bench, and a seventh



PERFORMANCE TESTS

hole can hold up to three pegs; when a fourth is hammered in this hole, a peg is ejected from the side of the bench. This method of hammer pegs "through the tunnel" was demonstrated to each child who was then permitted free play with the toy. The approach to the game, focus of interest, coordination and aim were noted. Particular note was taken of the development of an awareness of different depth holes and activity like probing holes during the game. Pegs also served as a color test (see below).

Some children were asked to play this game while wearing occluder masks; these were the same Hallowe'en masks as used in the toy test above. The purpose of this was to see if aim was significantly different with one eye alone, and whether there was any consistent deviation to either side. This idea of marked and consistent deviation from a central line was used in the next two performance tasks as well, line walking and ball rolling. It was thought that significant eccentric fixation, i.e. extramacular fixation might be suspected by such simple performance tasks. Actual determination of fixation necessitates a specialized ophthalmoscope-like instrument, the Visuskop.[69-71]

Walking lines. Walking lines was attempted in some children as a measure of the general eye-foot coordination, and a possible means of detecting eccentric fixation. With both eyes open, and then with each eye occluded in turn, the child was asked to walk a straight line made by the tiles on the living room floor when these were available. This was demonstrated as a heel-to-toe walk which might also detect ataxia.

Ball playing. Ball playing had several purposes. A bright orange rubber ball with a 7-inch diameter was used. General coordination and aim were noted; the manner of spontaneous throwing and catching were compared to patterns expected at the age of the child. The child was asked to roll the ball straight looking with both eyes, and then with each eye occluded. While each eye was occluded, the ball was rolled toward the child's side, and he was asked to fetch it. Observing the child's behavior in searching for this very large object gave an impression to compare with his behavior with two eyes open. Thus it was possible to judge whether he was normally binocular, i.e., the child who functioned well enough and equally with each eye alone but not as well as he did with two. The functionally monocular child could be detected by good function equivalent to that shown with both eyes in one eye and distinctly poorer function in the second eye.

Puzzle. A commercial puzzle graded "18 months on" was used in lieu of a geometric form board. It is wood and consists of a chartreuse background board and four separate pieces shaped to resemble types of fruit: purple grapes, red apple, orange pear, and yellow banana. This was chosen over a form board for its concretely represented form variation and its appeal as well as for its availability. The puzzle was taken apart and put together once in front of the child, and he was then asked to do the same; his motions were noted and timed. Reinstruction with verbal description was given when necessary, usually after 3 minutes of trial and error. Ability to match forms, distinguish landmarks of forms, and the right from the wrong side of a puzzle piece were noted.

Dominance

Interest in eye dominance and its relation to handedness and hemispheric dominance, and the correlation of these factors with reading—disability, speech disorders, visual acuity, have been the subject of much discussion and much controversy periodically. Numerous more or less complicated tests have been devised, and the literature is full of testimonies to the significance of one or more tests, and also to the worthlessness of almost all of them.[72-93]

The tests used in this study are subject to much of this criticism. They were performed to determine at what age dominance started to be established, and what the fact of having a dominant side meant. The eye dominance tests were three, all simple sighting tests: (1) an 8½ × 11 inch gray cardboard with a 1 inch center hole was handed to the child who was asked to peek through the hole while holding the cardboard with both hands; (2) a cardboard papertowelling tube, with a 1½-inch hole, was used to sight while held in both hands, the apparently dominant and the apparently nondominant hand; (3) a lorgnette-type occluder,[25] with a 1 inch hole, made of black paper was used to sight while held in each hand. The influence of eye dominance on effective occlusion especially with the lorgnette has not been determined.

Handedness, first of all, was not determined in any standardized manner; rather it was inferred from the child's use of one hand to write, indicate directions, hammer, and play ball, to the exclusion of the other hand, and, on the mother's statement made with certainty, that the child strongly preferred to use one hand for eating. When there was any use of the second hand for these activities, and when the mother expressed any doubt, handedness was judged "not established." Children who were ambidextrous with good dexterity, however, were judged to be left-handed, particularly when they seemed clearly left-eyed and there was a family history of left-handedness since left-handed people often tend to be ambidextrous. Secondly, none of the factors entering into the judgment of handedness was influenced by eyedness, i.e. the child was never totally blindfolded (except perhaps those severely amblyopic children who, with the good eye occluded, were functionally blind). The influence of handedness on eyedness was accounted for by notation of which hand was used while sighting.

Foot dominance was determined in some children by consistent use of one foot kicking a ball.

Color

Color awareness was observed in an attempt to judge when this becomes a factor in the child's dealings with his environment both for normal learning and growing and for design of vision tests. Children were asked to find another peg the same color as one the examiner picked up—usually red, yellow, or blue. If this was done successfully, the child was asked to name colors. This was done during the peg game and/or the block building. Ishihara series[94] were not used because they require that the subject identify a figure usually a number, within a mass of colored dots, and this task was considered beyond the capability of these children.

Questionnaire

Questions asked the mother concerned the child's development, his preference for current activities and his current abilities, past history of general medical illness, symptoms and signs suggestive of visual disorders. This afforded an opportunity to learn about the child himself past and present and to compare him to his peers. But it also gave some indication of the mother's awareness of the child, her concerns about his health, and her willingness to seek preventive medical care. It served to place any visual findings in the total framework of the child's medical and social background.

PARENT QUESTIONNAIRE

1. What name do you usually call child?..

2. Perinatal history
    a. pregnancy
    b. delivery
    c. birth weight...........

3. Developmental history
    a. When did baby seem to see?...................
    b. When did baby first smile?......................
    c. When did baby start to pick up toys?......................
    d. When did baby sit?.........pull to stand?.......walk?.....run?......
    e. When did he start to talk?......................
    f. How does he compare with your other children at the same ages?
        same, faster, slower...........................
        How?
    g. Did he ever seem cross-eyed or wall-eyed?.....when?....how long?..
    h. Does he dress himself?...............

4. What are his favorite activities?............Indoors?......Outdoors?........
    How long does he play at these?.............
    Games, puzzles, blocks, drawing
    Ball, bicycle
    Television.............since..............favorite programs.............
    Being read to.......since.................pictures identified...since.......
    pictures favored................
    Eating Does he feed himself?.......How long?.......How well?..........

5. What illnesses has he had?............Age?.....Complications?...........
    Did he take any drugs?...........Does he now?.................

6. Current eye symptoms
    a. rub or close eyes?....Do they water?......Are they bloodshot?.......
    b. complain of burning, headache, etc., after watching TV?.............
        carsickness?........
    c. seem uncomfortable in bright light?.......Does he shut an eye?......
    d. have trouble finding his way in the dark?........
    e. hold things close to face?.......sit close to TV?...........
    f. seem clumsy in games?........
        If child does squint, ask:
        (1) Has he had any illness with high fever?....how high?........
            How long did it last?..................
        (2) Has he ever been unconscious?....following a head injury?...
        (3) Has he had convulsions?....fever fits?.....other?.............
        (4) Measles?.....mumps?....whooping cough?...polio?........
        (5) Has one eye ever been bandaged for any reason?........

7. Has he ever been to an eye doctor?....where?........when?....why?.......

8. Does anyone in the immediate family have any eye trouble?..........
    Did anyone ever fail a driver's test or military exam because of eyes?........
    Does anyone wear glasses.......Who?........Why?.........Since.........
    Does anyone have a squint now?.......As a child?........

III. THE SUBJECTS

This study was carried out through a Well Child Conference (hereafter called W.C.C.) of the Boston Health Department situated in the Bromley-Heath Housing Projects at 10 Lamartine Street Extension, Jamaica Plain, Mass. This W.C.C. is conducted for demonstration and teaching by Harvard School of Public Health and Harvard Medical School. There are about 1,150 families living in the housing project, and about 2,300 of the 4,000 residents are children. There are equal numbers of Negro and white families. The social, economic, occupational and educational levels are low.

All children listed in the records of the W.C.C. public health nurses who lived within the project and had birthdays between December 1958 and December 1959 were included for this study which was done August 1 to October 16, 1962. This group was chosen because of the "borderline" age for testability in traditional preschool vision testing—about 3 years, and it was hoped that some visual trend in the few months before age 3 and in those months after the third birthday could be established. There were 105 children in this age group in the W.C.C. records, and an additional 9 were picked up as the study progressed, making a total of 114 children. The "pickups" were siblings who were also of preschool age, or 3-year-old children who appeared in the W.C.C. for the first time during the course of the study.

Of the 114 children, 10 had moved some time in the 6 months prior to testing. Of the 104 children contacted, 10 refused to participate for various reasons. Of particular interest among the refusals were two children who had eye problems and were under care elsewhere: one, a child with esotropia, had been referred from the W.C.C., was under treatment by an ophthalmologist, and the mother did not want to confuse the child with another eye test; the other was a child with allergies manifested by conjunctivitis, and again the parents thought she was having "enough eye care" (local, private doctor). Two mothers were ill and unable to cooperate because the children were placed in foster homes for the duration of the mother's indisposition. Two mothers, with poor records of clinic attendance, were "too busy." Three, fearing the mad strangler, would not open the door. One child with phenylketonuria was so retarded that the mother thought it pointless to detect any other problems he might have. Thus, 94 of the 104 available children (90 percent) accepted and were tested.

Of the 94 children studied, 25 were from families called "uncooperative" for poor clinic attendance. Five of these children had never been to clinic, and the other 20 had not been since early infancy. The families were known because of initial home visits made by the nurse or clinic visits with other children. Eight of these families showed evidence of extremely poor general care and low motivation when visited. The other 17, however, seemed fairly well organized and at least 14 of these stated they were receiving ongoing medical care from other sources—hospital out-patient departments (Boston City, Children's Medical Center, Chelsea Naval, Boston Floating, and Beth Israel), and local private doctors.

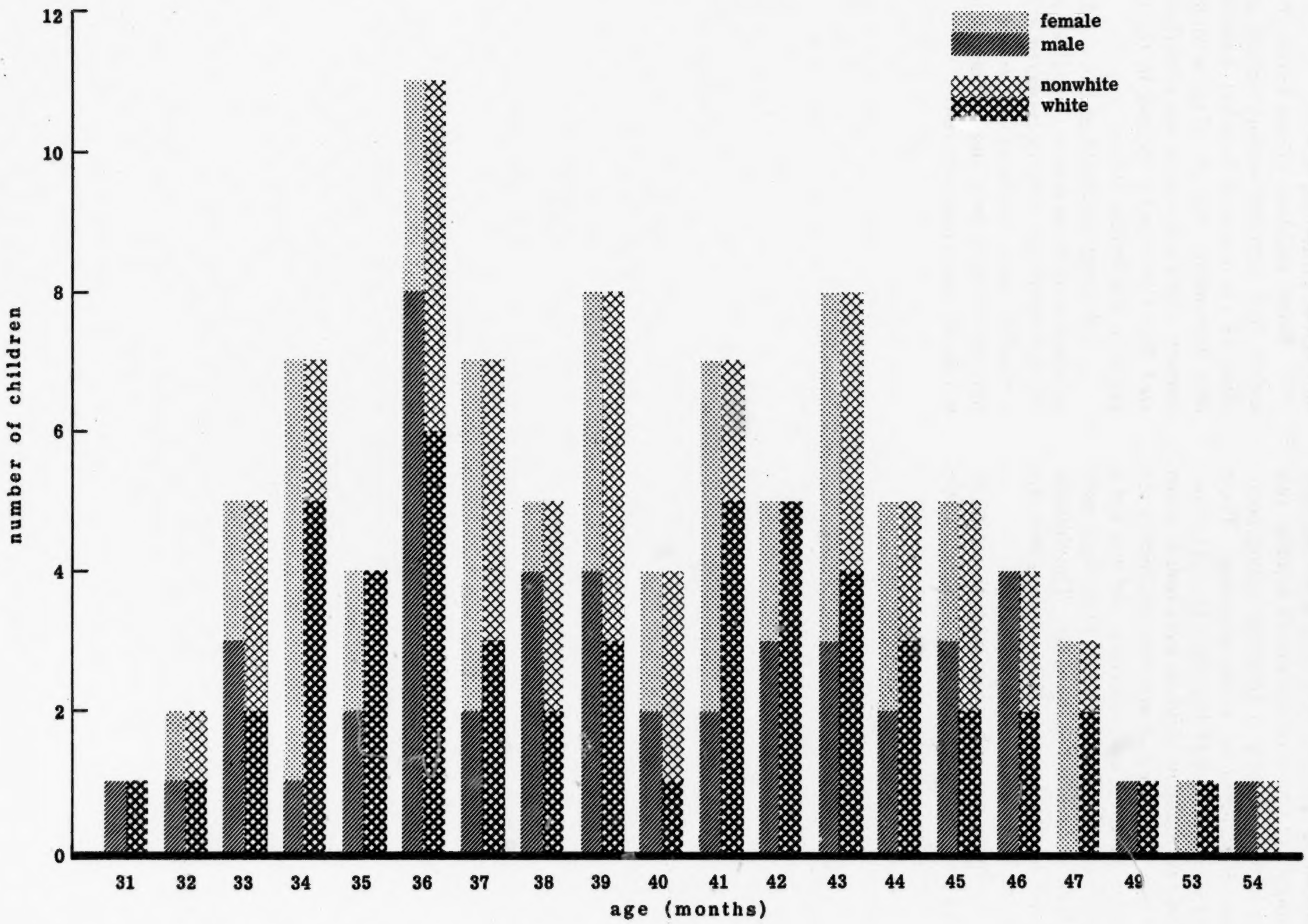
The 94 children tested (see fig. 1) ranged in age from 31 to 54 months; the "extra" children at the extremes are accounted for by errors in recording ages and the testing of several older siblings. The median age was 39 months; this was, in other words, an unusually young population of children for vision screening. There were 47 males and 47 females. In eight situations, two different children were tested; seven of these were families with two children in the age range (three sets of twins), and one was a foster home for two children. Thus, there were 87 families involved in the study. The children studied had an average of 2.9 siblings each, 2.3 older and 0.6 younger.

There were 53 white and 41 nonwhite (part or all Negro) children. Three Puerto Rican children were included. The families of 66 children were "intact", and 28 children were motherless, fatherless, or both.

Seven children (three males, four females) had attended nursery school, and another 21 (12 males, 9 females) were starting that September. For all of these 28 children, nursery school association was with the Associated Day Care Center located in the housing project at 262 Parker Street.

All except five children had checks or no comment about their eyes on their clinic records. The five notations were for transient erythema, torticollis, early inability to follow lights, plugged lacrimal duct, and an unexplained reminder to "check eyes next visit."

FIGURE 1: AGE DISTRIBUTION OF SUBJECTS BY SEX AND RACE



IV. OPERATING PROCEDURES

Preliminary tests were given to two children in one family after arrangement was made with the district nurse. All other meetings were arranged directly, following an introductory letter. Groups of 10 mothers at a time, arranged geographically, were contacted by this letter which explained the nature of the study and stated when the examiner would visit. District nurses were informally aware of which families were being contacted. This first visit was intended to make the testing date for some convenient time in the family schedule, and to obtain answers to the questionnaire. It took anywhere from 5 to 30 minutes per family depending on the number of questions the mother asked and whether the questionnaire was actually completed. It became apparent soon after this visiting started that time and schedules are not important factors in the lives of many of these families. Although almost all of them acknowledged having received the letter, most said they had forgotten the day of the visit. There was at most an interval of one week between mailing the letter and visiting. It was often necessary to revisit numerous times on subsequent days in order to make a testing appointment. It became much more efficient to delay the questionnaire for the testing session when there tended to be more time for this, during those test activities which seemed to consume time beyond their immediately informative value. Thus, the first visit was shortened to 5 or 10 minutes. This overall average time was almost 30 minutes though because of the large number of visits necessary in some cases. This first visit could be unnecessary if a familiar person like the public health nurse were to do the testing, but multiple visits for contacting some families seem inevitable.

It was decided that testing in the homes would be preferable to testing at the W.C.C. It was thought that the disadvantages of poorly standardized environment, interference from parents and siblings, and imposition on the family would be outweighed by the advantages of a flexible schedule, opportunity to talk with the mother at leisure, and observe the child in his natural environment. The available building was very often occupied with day camp and clinic activities, and the aura of a clinic visit to most children might have detracted from their readiness to cooperate. Fifty of the children might have come to the W.C.C. for testing; these were generally cooperative families and mothers who were concerned about the possibility of eye problems. Thirty-seven said they would not come to the W.C.C. for the test but were willing to have the tests brought to them. Seven were not even willing, before extended clarification and discussion, to have the tests done at home; reasons ranged from fear of eyedrops to concern about what the procedure would cost.

The entire procedure was construed as a play session, and it was not unusual for the children to request a return visit despite occasional initial anxiety at the word "doctor." Mothers tended spontaneously to call the examiner "teacher" and many children seemed to enjoy feeling this was like school.

Most mothers were home at the appointed time, but many volunteered that they had forgotten the appointment, and the child was often outdoors, asleep, or away. The entire procedure took an average of 1½ hours. The most time consuming tests were consistently the performance tasks; because of their appeal as real games it was difficult to cut them short, and they often tended to function more as transitional energy expenditure than as tests in themselves. The time for each individual test varied greatly with the child's capacity and interest, and it is impossible to state meaningful averages.

The tests were carried in a shopping bag, and an effort was made to use all the tests except where there was obvious lack of cooperation or interference. The order varied from child to child, and there was no set number of times for reintroduction of tests which failed initially. An appealing toy was used as an introduction—usually the ball or a puzzle. Somewhat abstract tests were interspersed with physical activity, and it was thus possible to retain the child's attention for long periods of time, at least up to 2 hours, and to relieve both fatigue and tension. Notes were taken during testing and later transcribed onto mimeographed forms.

When 40 children were retested 6 months later, it was interesting to note that although 5 mothers stated they had misinterpreted the letter and thought they were supposed to go to the W.C.C., only 1 actually did go. The revisiting necessary was again in excess of what might be expected. Optimally, i.e. when consecutive families were home, 5 retests an hour could be done. However, a total of 11 hours were necessary in order to retest 36 children—the actual tests taking little over 7 hours. This is again a problem that might be obviated if the nurse were doing the testing.

Summary cards were kept for each child listing all basic identifying information, appointments and a summary of the test findings.

V. FINDINGS

Testability and nontestability on individual tests

Most of the eight types of tests were attempted with most of the subjects. Children were testable with each procedure according to the definition established for the purposes of the study and summarized in table 1. The total numbers and percentages of children tested and found testable with each procedure are shown in table 2.

Table 1.—SUMMARY OF DEFINITIONS OF TESTABILITY

Test	*Testability is defined as*
Visual acuity—"Stycar:"	
Matching letters	Three or more letters successfully matched.
Near letter test	Consistent matching of 3 or more letters with or without occluder at 12–16 inches.
Distant letter test	Consistent matching of 3 or more letters with or without occluder at a distance greater than 5 feet.
Miniature toy test:	
2 eyes	Naming or matching 2 or more toys consistently and correctly at a distance of at least 5 feet.
Each eye	Naming or matching 2 or more toys consistently and correctly at a distance of at least 5 feet while wearing occluder.
Visual acuity—Naming pictures and toys:	
Picture tests (Allen, Osterberg, A.O.)	Naming 4 or more pictures on any of the 3-picture series at close range without occluder.
Toys	Naming 4 or more toys at close range without occluder.
Visual acuity—Indicating directions:	
Drawing	Copying the demonstrations well enough to accurately reproduce at least the vertical and horizontal line.
Sjogren hand	Indicating 2 or more directions consistently and correctly at close range without occluder.
Snellen E	Indicating 2 or more directions consistently and correctly at close range without occluder.
Visual acuity—Eliciting:	
Opticokinetic nystagmus	Showing nystagmus when tape moves right to left and left to right, without occluder.
Muscle balance:	
Penlight following and nearpoint of convergence	Following the light in all directions and converging on it.
Cover test	Cooperating sufficiently to allow reproducible observation.
Red glass test	Giving plausible answers to the test question.
Stereoscope	Looking correctly and reporting an observation for at least one of test cards.

Test	*Testability is defined as*
Performance:	
Blocks	Reproducing at least 1 of 3 constructions demonstrated (tower, bridge, or train).
Peg bench	Participating in any way which makes possible an estimation of depth perception and comparison to peers.
Walking line	Walking a straight line with and without an occluder.
Ball playing	Playing with the ball with another person in any way, with or without occluder.
Puzzle	Participating in any way which gives indication of ability to perceive and recall shapes and permits comparison to peers.
Dominance	Sighting (even partially) through at least one of the devices used.
Color	Matching and/or naming colors consistently and correctly.

All of the tests could not be attempted with all of the children. Those tests which required some abstract thought, particularly the Stycar letter test, and the direction tests, sometimes did not attract enough attention to make instruction and testing possible. Some equipment, e.g. the stereoscope and nystagmus tape measure, periodically disappeared and these tests were necessarily omitted until test materials were recovered. Since the tests were never given in a prescribed order, there was an occasional omission caused by oversight, usually in situations where more than one child at a time was being tested. Some tests were purposely discontinued after a number of children had been examined, because they seemed inappropriate to this age or especially uniformative.

Visual acuity—"Stycar"

Matching letters. In general, the children did not find this letter test attractive; there was little enthusiasm displayed even by those who could competently match letters. The test could not be attempted with 25 children who either ignored these particular test materials when they were shown repeatedly or were so generally uncooperative and hyperactive that the futility of proceeding beyond the showing was obvious. Those 59 children with whom the test was attempted (tables 2 and 3) were those whose attention was good enough to permit explanation of the procedure.

The 26 children who were able to perform the required matching procedure for a minimum of three letters were considered testable (table 1) and the other 33 children were nontestable. Many of these nontestable chil-

Table 2.—TESTABLE CHILDREN

Totals for Each Test

Test	Attempted No.	Testable No.	Percent
Visual acuity "Stycar":			
Matching letters	59	26	44
Near letter test	23	22	96
Distant letter test	21	10	48
Miniature toy test—			
2 eyes	94	80	85
each eye	94	60	64
Visual acuity—Naming pictures and toys:			
Pictures	93	67	72
Toys	43	29	67
Visual acuity—Indicating directions:			
Drawing	89	61	69
Hand	72	42	58
E	70	21	30
Visual acuity—Eliciting opticokinetic nystagmus	77	50	65
Muscle balance:			
Penlight following and N.P.C	80	67	84
Cover	59	32	54
Red glass	12	2	17
Stereoscope	68	26	38
Performance:			
Blocks	85	80	94
Peg bench	91	91	100
Walking lines	19	16	84
Ball playing	89	82	92
Puzzle	94	94	100
Dominance	94	57	61
Color	84	36	43

Table 3.—VISUAL ACUITY—"STYCAR"

Testable and Nontestable Children (Breakdown by Sex, Race, and Age)

Test	Sex		Race		Age (months)																			
	M	F	N	W	31	32	33	34	35	36	37	38	39	40	41	42	43	44	45	46	47	49	53	54
Matching letters:																								
Attempted	28	31	24	35	---	1	---	4	1	5	5	5	4	2	4	3	7	4	5	3	3	1	1	1
Testable	14	12	11	15	---	---	---	---	1	1	1	1	2	---	1	3	5	1	2	3	3	1	---	1
Nontestable	14	19	14	20	---	1	---	4	---	4	4	4	2	2	3	---	2	3	3	---	---	---	1	--
Near letter test:																								
Attempted	12	11	9	14	---	---	---	---	1	2	1	---	2	---	---	3	5	1	1	2	3	1	---	1
Testable	11	11	9	13	---	---	---	---	1	1	1	--	2	---	--	3	5	1	1	2	3	1	---	1
Nontestable	1	0	0	1	---	---	---	---	---	1	---	---	---	---	---	---	---	---	---	---	---	---	---	--
Distant letter test:																								
Attempted	11	10	10	11	---	---	---	---	---	1	---	---	2	---	---	3	6	1	2	2	3	---	---	1
Testable	5	5	5	5	---	---	---	---	---	1	---	---	---	---	---	2	2	---	1	---	3	---	---	1
Nontestable	6	5	5	6	---	---	---	---	---	---	---	---	2	---	---	1	4	1	1	2	---	---	---	--
Miniature toy test:																								
Attempted	47	47	41	53	1	2	5	7	4	11	7	5	8	4	7	5	8	5	5	4	3	1	1	1
Testable—2 eyes	39	41	34	46	---	2	4	5	4	9	5	3	7	4	7	5	7	5	4	3	3	1	1	1
Nontestable—2 eyes	8	6	7	7	1	---	1	2	---	2	2	2	1	---	---	---	1	---	1	1	---	---	---	--
Testable—each eye	30	30	26	34	---	2	1	5	1	7	2	3	5	3	4	4	7	4	4	3	3	1	---	1
Nontestable—each eye	17	17	15	19	1	---	4	2	3	3	5	2	4	1	3	1	1	1	1	1	---	---	1	--

dren were able to match only the "O"; a few more could distinguish the "X" or "V" but confused these two letters. There seemed to be enhanced interest and accuracy in this test when the child used pennies to cover the appropriate letters on the key card instead of pointing to the matching letter.

This ability to match letters made possible actual visual acuity measurement in the children who continued to match under the conditions of (b) the near letter and (c) the distant letter tests.

Near letter test. Of the 26 children who were testable (table 1), there were 23 who sustained enough interest in the letter matching operation to take the near visual acuity test; the 3 children with whom the near test was not attempted had refused to play at matching or the acuity test after they had successfully matched the three letters required for minimum testability.

With one exception, the children seemed to enjoy this near test more than the practice matching. A possible explanation was offered by one child's mother who suggested that he was overwhelmed by the mass of letters on the near test card, and that his ability to match depended on the presentation of single large symbols.

The near test was done with both eyes in all 23 children and also with each eye separately in 20 children. Those who were not tested with mask occluders were children who did not accept occlusion for any test. Two of these three children were called testable (tables 1 and 2) since they could perform the required operation. If, however, the primary objective of including this test had been amblyopia detection, i.e. if it were the only visual acuity test performed, these two children would not have been considered testable.

Distant letter test. None of the children who successfully matched letters was able to sustain interest long enough to learn the procedure and then take near and distant tests consecutively. The distant test was therefore usually given some time after the near test. It was possible to attempt this in only 21 of the 23 children who took the near test; the other two children became too tired and distracted to attempt the distant test. There was generally great fascination with the mirror placed 10 feet away, but this arrangement made matching more difficult.

Although, no doubt, distance itself was a large factor, the mirror seemed to be distracting, and it was often difficult to illuminate the letters well. Of the 10 children who were able to successfully match letters at least with both eyes, at some distance, 8 matched 20 feet away (the mirror was 10 feet away), 1 matched 10 feet away (the mirror was 5 feet away), and 1 matched letters 6 feet away without the mirror.

Miniature toy test. This was the only test that could be systematically administered as a distant visual acuity test to most of the children. In general, the children found these toys and this test very appealing. Children who could not name pictures, could either name these or indicate their function in play, and match them. Sometimes, the toys seemed to be almost too attractive; there was much dawdling, initial play with the toys, and pauses during the test to put the doll on the chair or see if the car wheels worked. The airplanes were so attractive that they both disappeared by the fourth test, and other toys sporadically followed. It was possible to function with only a single set with those children who named rather than matched; the less verbal children who needed to match seemed content to match not quite identical toys, i.e. dime store replicas, to the test materials. Thus, it was possible to attempt the test with all 94 children.

There were two children who matched according to color rather than form; this supposedly more primitive type of match was more noteworthy for its absence in the other children, many of whom had toys arranged so that the white chair might have been matched with the white car. After these two children, special care was taken to keep all objects of one color in one set.

Two eyes: The 80 testable children (table 1) were more or less able to follow the test instructions. The 14 children who could not be tested at all with this test did not display any comprehension or interest in any of the other tests. On this test they did not accept any preparatory instructions although they did play with the toys.

Each eye: The test was only successful as an actual measure of visual acuity in those 60 children who matched or named the toys at a distance while wearing occluders.

The 20 children who were not differentially testable would not accept the mask occluder for this test; 5 of them did accept occlusion for performance tasks, especially the ball. Table 4 shows rejection of the occluder by sex and age; this rejection was sporadic but frequent before 37 months, and acceptance was the rule after 41 months. Of the 60 who were testable, 59 used the mask occluder, and one who refused the mask was tested with his mother holding the lorgnette. Of the 59 who wore the masks for the test, 47 accepted them readily and accepted the right as well as the left mask; the other 12 were slow to accept the masks and obviously unhappy with them, taking them off several times during the test, needing reassurance that the occlusion was temporary, and having to be tested with great speed to take advantage of the short-lived mask acceptance.

Visual acuity—Naming pictures and toys

Pictures. At least one of the three picture series was shown to all subjects (with one oversight), and an attempt was made to test recognition of these figures. Actual measurement of visual acuity was not attempted formally, i.e. there was no distance assumed between examiner and subject and no occluders were used.

All the children, except two, preferred

Table 4.—OCCLUDER REJECTION (by Sex and Age)

	Sex		Age (months)																			
	M	F	31	32	33	34	35	36	37	38	39	40	41	42	43	44	45	46	47	49	53	54
Number rejecting mask	9	11	---	---	3	---	3	1	3	---	3	1	3	1	---	1	---	---	---	---	1	--
Number children tested	39	41	---	2	4	5	4	8	5	3	8	4	7	5	7	5	4	3	3	1	1	1
Percent rejecting mask	23	27	---	---	75	---	75	13	60	---	37	25	43	20	---	20	---	---	---	---	100	--

the Osterberg chart and four children would name these pictures and none of the other picture tests; the two who preferred the Allen seemed intrigued with the little booklet form of the test rather than with the pictures themselves. In general, there was most delight with the Osterberg, and it was surprising that many of the figures were correctly named despite an expectation that they would be unfamiliar, e.g. the skeleton key and scissors. The Allen cards were called more unusual names than the Osterberg figures, e.g. the Christmas tree was called a "lamp", and a "lady's hat," and the birthday cake was often "fire" or "fire on plates." The A.O. was generally unappealing; few children knew four of the figures, hand, "coffee" (for cup) and "valentine" (for heart) were the most frequent responses. Few children recognized the sailboat, and the other figures were named only when a concrete figure was made of them, e.g. "wheel" for circle, "window" for cross, "sky" for moon or star or flag (with star on it).

Children were considered testable when four pictures were correctly named (table 1) because the Allen test series [25,27] which has the fewest pictures utilizes a passing criterion of four out of the seven cards. The Osterberg chart with 12 pictures and the A.O. with 8 could be used as acuity tests if 4 pictures are consistently identified.

A Spanish speaking child was considered testable (tables 2 and 5).

Table 5.—VISUAL ACUITY—NAMING PICTURES AND TOYS

Testable and Nontestable Children (Breakdown by Sex, Race, and Age)

Test	Sex		Race		Age (months)																			
	M	F	N	W	31	32	33	34	35	36	37	38	39	40	41	42	43	44	45	46	47	49	53	54
Pictures																								
Attempted	46	47	41	52	1	2	5	7	4	10	7	5	8	4	7	5	8	5	5	4	3	1	1	1
Testable	31	36	29	38	---	1	3	2	3	8	4	3	5	3	5	4	8	5	4	3	3	1	1	1
Nontestable	15	11	12	14	1	1	2	5	1	2	3	2	3	1	2	1	---	---	1	1	---	---	---	--
Toys																								
Attempted	23	20	18	25	1	2	3	4	2	5	1	2	2	1	5	2	3	3	2	---	2	1	1	1
Testable	13	16	14	15	---	1	1	2	1	3	1	---	2	---	4	1	3	3	2	---	2	1	1	1
Nontestable	10	4	4	10	1	1	2	2	1	2	---	2	---	1	1	1	---	---	---	---	---	---	---	--

One child communicated by cleverly matching pictures on the charts with objects in her home; she was, for this tabulation (tables 2 and 5), however, considered nontestable because she could not have been tested under ordinary conditions.

There were 17 children in the group of 26 nontestables (tables 2 and 5) who hardly spoke at all during the exam. Nine of these could not express themselves verbally to anyone besides parents. Of these nine children there were five whose mothers expressed particular concern and the other four had a family history which made this seem normal. Of the testable children 38 did not speak well for their age; only 29 (13 boys, 16 girls) had very good verbal ability.

Toys. The toys were not shown, after the first few tests, to those who readily identified pictures because they were more distracting than informative. It is assumed that the 51 children who were not specifically asked to name toys (other than those in the toy acuity test) might have done so, based on their verbal prowess on other tests. A specific attempt to determine recognition of toys was made with only 43 children (table 2 and 5).

Three dimensional toys, including those in the miniature toy test, were *not* named by 14 children (tables 2 and 5); however, 3 of the "nonspeakers" could name these toys and 12 children who could not name enough pictures on charts to be considered testable (table 1) could name the toys. These children seemed to lack interest in the diagrammatic pictures; there seemed not to be so much a failure of perception as a lack of appeal. The toys were named only by withholding them from use until they were named, and this motivation to find a word was not so great for the picture charts as for the real toys.

Visual acuity—Indicating directions

Drawing. Drawing was attempted with the 89 children who cooperated to the extent of holding a crayon and writing on a paper. It could not be attempted at all with five children who would not accept these materials. The 29 children who were nontestable did not follow demonstration drawings, walked away and scribbled on their own, or in spite of apparent attention were unable to control their writing well enough to imitate the examiner's demonstrations.

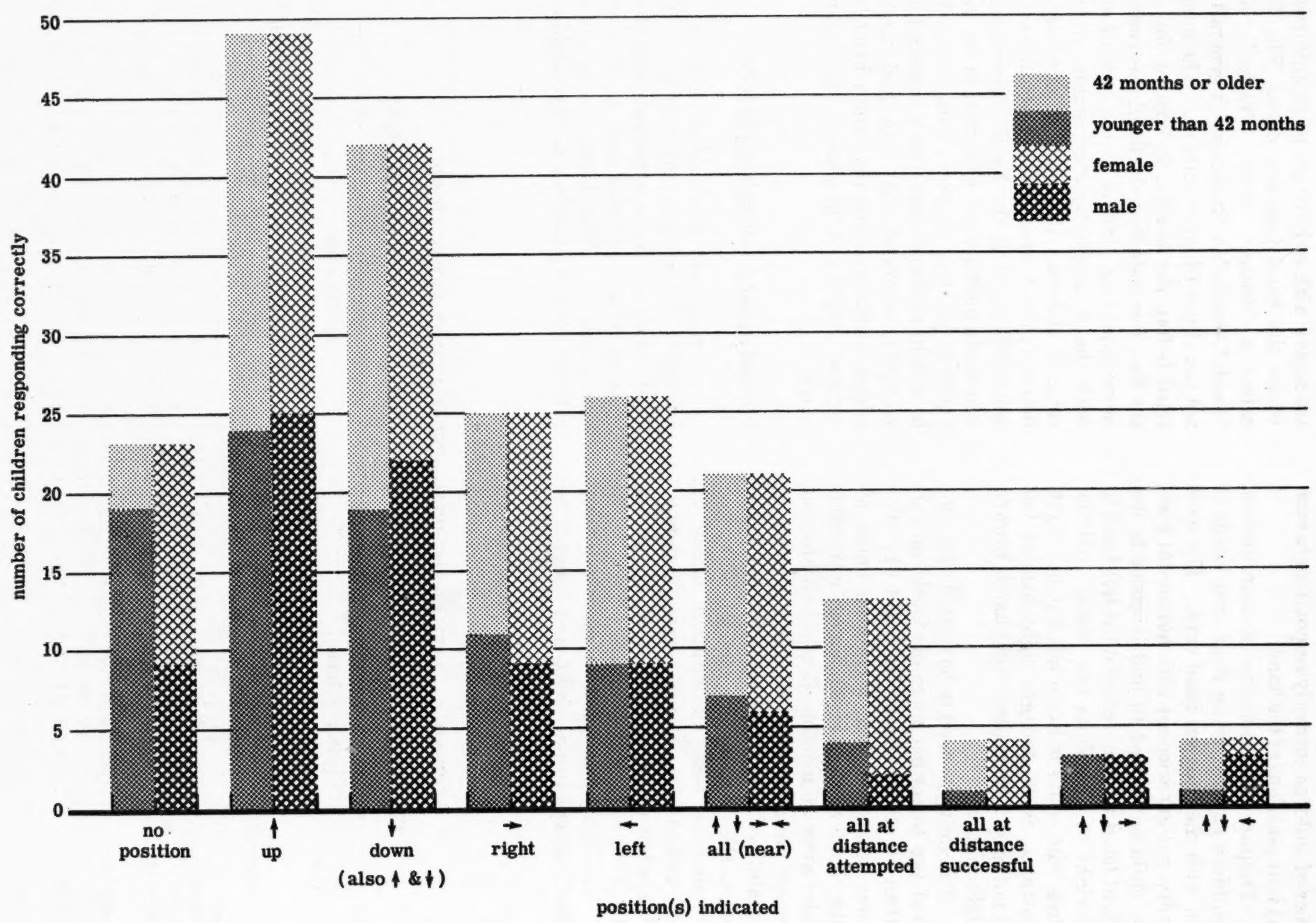
It was striking how few children could draw more than the vertical and horizontal lines and the circle; 3-year-olds are normally expected to be able to copy these. Those who were diligent and copied the other forms indicated oblique directions incorrectly as often as correctly, and paid no attention to where the opening in the circle was when making a "C" or a "U." Children who could copy the E had difficulty with the number of lines as well as with their direction; they frequently made five parallel horizontal lines as a reproduction of this letter. In general, the older the child, the more careful the copying and the fewer were the spontaneous scribbles.

Although children were considered testable (table 1) if only a vertical and horizontal line were produced with fidelity, this degree of ability might not be adequate for an acuity measurement. Children seemed to enjoy writing with direction more than indicating direction alone, and direction sense seemed better developed when the child wrote. The crayons and paper seemed appealing in themselves, and having to do exactly what the examiner had done seemed to increase motivation.

Hand. The hand card on repeated showings elicited some response from only 72 of the children; with these the test was attempted, i.e. instruction in directions was pursued. Most of the 72 children enjoyed looking at the hand card and calling it a "hand" or "glove," "mitten" or "elephant."

However, the ability to match directions was limited, even at conversation distance while touching the test card, and the assumption of any greater distance between examiner and child diminished this matching ability (see fig. 2) particularly for horizontal (right and left) positions. Only 42 of the 72 children could be considered testable (table 1) by the criterion used, because only 2 correctly indicated positions are necessary to make a child testable. This was the criterion set for this study, although the usual passing criterion is three of four positions. Figure 2 shows the

FIGURE 2 CORRECT RESPONSES TO DIRECTION TEST (HAND) BY POSITION, BY AGE AND SEX



number of children correctly responding to each of the four positions of the hand.

Despite some difficulty in coordination, the children enjoyed using their own hands to match with the Sjogren hand card. The most difficulty was experienced with horizontal positions; children seemed to find it easier to use the right hand to point left and the left hand to point right or sometimes vice versa. All the children who could indicate left but not right, for instance, were strongly right handed but could not seem to turn their right hands toward the right (fig. 2).

Testability seemed to be related to chronological age somewhat more obviously on this test than on others (see tables 2 and 6). The test was attempted with 9 children under 36 months, and 8 of them or 89 percent were nontestable; after 36 months, 41 of 63 children or 65 percent were nontestable. This decrease in nontestability is most striking when 42 months is used as the dividing line (fig. 2). The test was attempted with 42 children under 42 months, and 24 of them or 57 percent were nontestable; after 42 months, only 6 of 30 children or 20 percent were nontestable.

"E." This test was less appealing than the hand, except to one child, and it could be attempted with only 70 of the 72 children with whom the hand test was done. The E was called a "letter," "fork," "table," "hand," "comb," "tooth," or "nothing;" it generally was not the object of much interest. The hand was tried before the E after it became obvious in the first few tests that the hand was easier and more appealing. Some of the lack of success with the E might be attributable to fatigue since it followed the hand in most sessions; however, the E also seemed to be intrinsically more difficult than the hand. Those children who could match the E preferred to use the cutout E rather than their own hands; it seemed to be a help to match something exactly like the E figure, whatever that was, and there was added confusion when the child's hand had to serve as a replica of the abstract and unfamiliar letter.

Visual acuity—Eliciting OKN

In general, the children found this test intriguing for a short period of time. In the 77 children who were presented with the tape measure, an attempt was made to elicit nystagmus (table 2). The failure to attempt this with the other 17 children is attributable to the

Table 6.—VISUAL ACUITY—INDICATING DIRECTIONS

Testable and Nontestable Children (Breakdown by Sex, Race, and Age)

Test	Sex		Race		Age (months)																			
	M	F	N	W	31	32	33	34	35	36	37	38	39	40	41	42	43	44	45	46	47	49	53	54
Drawing:																								
Attempted	42	47	39	50	---	2	4	6	4	10	7	4	9	4	7	5	8	5	5	4	3	1	1	--
Testable	27	34	23	38	---	---	1	2	2	5	4	3	8	3	4	5	7	5	4	3	3	1	1	--
Nontestable	15	13	16	12	---	2	3	4	2	5	3	1	1	1	3	---	1	---	1	1	---	---	---	--
Hand:																								
Attempted	33	39	32	40	---	1	---	6	2	9	5	2	8	3	6	4	8	4	5	3	3	1	1	1
Testable	21	21	20	22	---	---	---	---	1	4	2	2	3	2	4	3	8	3	3	2	3	---	1	1
Nontestable	12	18	12	18	---	1	---	6	1	5	3	---	5	1	2	1	---	1	2	1	---	1	---	--
E:																								
Attempted	32	38	31	39	---	1	---	5	2	8	5	2	8	3	6	4	8	4	5	3	3	1	1	1
Testable	9	12	11	10	---	---	---	---	1	---	---	2	1	1	3	2	2	1	3	1	2	---	1	1
Nontestable	23	26	20	29	---	1	---	5	1	8	5	---	7	2	3	2	6	3	2	2	1	1	---	--

periodic disappearance of the tape. Those children considered testable (table 1) were able to follow the instructions and sustain interest long enough to complete the task. The nontestable children showed partial response and were easily distracted or did not respond at all. Those who did not sustain interest seemed to follow the end of the tape rather than fixate the lines; the response was elicited in the first direction or in the first moments but not continued. Those with no nystagmus either never approached closely enough or looked past the moving tape. These patterns of response are summarized in table 7 below by sex, race, and age.

There were four children who had good horizontal nystagmus in whom vertical nystagmus was stimulated, but at best there were a few jerks of small amplitude, and this direction seemed to have nothing to recommend it.

An incidental observation was that the green side of the tape produced noticeably slower nystagmus than the white side. This change of background color or decrease in contrast may be useful for slowing down the response enough to observe it more carefully, but probably tends to lower the level of acuity measurement.

Muscle balance

Muscle balance tests were uniformly difficult to administer because of inadequate cooperation from the children, and because they usually called for totally subjective judgments on the part of the examiner.

Nearpoint of convergence and penlight following. Determination of N.P.C. and ability to follow the light was attempted with 80 of the 94 children, those who were tested when the penlight was present and intact. All the children who were willing to follow the light also converged upon it and since this was one operation, the findings are tabulated together. Only 13 children, those called nontestable (tables 2 and 8), did not approach the examiner and did not follow the light.

It was very helpful in gaining cooperation on this test to have the child try to "blow out the light;" this drew the children close enough for observation, and seemed to be such

Table 7.—VISUAL ACUITY—ELICITING OKN

Testable and Nontestable Children (Breakdown by Sex, Race, Age, and Type of Response)

Response Pattern	Sex		Race		Age (months)																			
	M	F	N	W	31	32	33	34	35	36	37	38	39	40	41	42	43	44	45	46	47	49	53	54
Attempted	38	39	33	44	1	2	2	5	5	11	6	3	7	3	6	4	6	3	5	4	2	1	---	1
Testable	23	27	24	26	---	1	1	3	2	8	3	3	6	2	4	3	4	1	2	4	2	1	---	--
Equal sustained response—both directions	22	25	22	25	---	1	1	3	2	8	3	3	5	2	4	3	4	1	1	3	2	1	---	--
Response one direction more than other consistently	1	2	2	1	---	---	---	---	---	---	---	---	1	---	---	---	---	---	1	1	---	---	---	--
Nontestable	15	12	9	18	1	1	1	2	3	3	3	---	1	1	2	1	2	2	3	---	---	---	---	1
No response	6	9	3	12	---	---	1	1	3	1	2	---	1	---	1	---	1	2	2	---	---	---	---	--
Response in one direction only	9	3	6	6	1	1	---	1	---	2	1	---	---	1	1	1	1	---	1	---	---	---	---	1

Table 8.—MUSCLE BALANCE

Testable and Nontestable Children (Breakdown by Sex, Race, and Age)

Test	Sex		Race		Age (months)																		
	M	F	N	W	31	32	33	34	35	36	37	38	39	40	41	42	43	44	45	46	47	49	53	54
N.P.C. and Penlight Following:																								
Attempted	36	44	34	46	1	2	1	6	4	10	4	5	8	4	5	5	8	5	5	3	2	1	---	1
Testable	30	37	30	37	1	2	---	4	2	8	3	4	8	4	4	5	8	5	4	3	2	---	---	--
Nontestable	6	7	4	9	---	---	1	2	2	2	1	1	---	---	1	---	---	---	1	---	---	1	---	1
Cover test:																								
Attempted	25	34	30	29	---	2	1	4	3	8	3	2	4	3	4	5	6	5	3	1	3	---	1	1
Testable	11	21	19	13	---	1	1	---	2	3	1	1	1	2	2	2	5	4	2	1	2	---	1	1
Nontestable	14	13	11	16	---	1	---	4	1	5	2	1	3	1	2	3	1	1	1	---	1	---	---	--
Red glass test:																								
Attempted	7	5	6	6	---	---	---	---	---	3	2	1	1	---	---	1	---	2	2	---	---	---	---	--
Testable	1	1	1	1	---	---	---	---	---	1	---	---	---	---	---	---	---	---	1	---	---	---	---	--
Nontestable	6	4	5	5	---	---	---	---	---	2	2	1	1	---	---	1	---	2	1	---	---	---	---	--
Stereoscope:																								
Attempted	31	37	28	40	---	1	1	5	3	7	6	3	8	4	---	6	5	7	2	5	3	1	---	1
Testable	12	14	12	14	---	---	---	1	1	1	3	1	3	2	---	2	3	3	1	2	2	1	---	--
Nontestable	19	23	16	26	---	1	1	4	2	6	3	2	5	2	---	4	2	4	1	3	1	---	---	1

a fascinating phenomenon to them that it made their cooperation worthwhile.

Behavior on touching the light at varying distances and threading it with the scissors varied with general maturity. Those children who were better coordinated did this easily usually with the index finger of one hand or holding the scissors in one hand. The younger and less coordinated used the right hand for the right visual fields, the left for the left, and grasped the scissors in both hands. In seven children there seemed to be definite tremors and distinctly poorer coordination to one side. Only one of these children had a significant intention tremor which seemed to be combined with a field defect; she functioned normally according to her family, had been a premature and had had "spinal meningitis." The other six were difficult to interpret, considering other test results in the same cases.

Cover test. The limitations of the examiner's eye and experience make the accuracy of this test particularly questionable. Impressions of imbalance on this test were usually not corroborated on other tests despite optimal cooperation. The near cover test was attempted only with 59 of the 67 testable children on the NPC; these 59 seemed able to fixate the light. It was possible to make reproducible observation repeatedly in those children called testable (tables 1, 2, and 8), but even in these cases there might have been minor deviations which were not noticed. In most cases, it was easier and less ambiguous to observe the position of corneal reflections relative to one other, and to question muscle imbalance on this basis.

Red glass test. Soon after the study began, it became clear that the concept of number and color was inadequately developed at this age to make this test at all useful. The test had been attempted with 12 children when the decision to discontinue it was made. Only 2 children (testable on tables 2 and 8) gave answers which were at all plausible possibilities and these may well have been fortuitous; the other 10 reported seeing e.g. "three lights—black and blue."

Stereoscope. The stereoscope was available when 68 children were tested and an attempt was made to get these children to look into the instrument and report their observations. Their reactions fell into five categories only one of which could be considered testable (tables 2, 8, and 9). These categories and the children showng each type of response are summarized in table 9 below by sex, race, and age. Those six who looked and reported (a) unfeasible answers made it impossible to determine if there was fusion. The 17 who looked into the instrument correctly (b), but did not report any observation were not nonspeaking children, but rather a group made speechless by the task. The eight who never looked through correctly (c), peeked over the top, to the sides, and approached with the wrong eye to the lens. Eleven (d) refused to approach the stereoscope closely enough to make an observation.

Performance

Blocks. This test was attempted with 85 children (tables 2 and 10). When this was not included, the usual reason was interference from siblings (especially when two children were tested together) or extreme uncooperativeness. Children who were shown demonstrations but either ignored or destroyed them were nontestable, while those who copied or imitated at least one demonstration were considered testable (table 1); a minimal amount of performance was necessary to make the child testable or comparison with peers possible.

This was usually very appealing to the children despite the fact that, in describing favorite play activities, most mothers said blocks had been outgrown, or confiscated because they had been used to hit siblings. The patterns of building with these large blocks followed patterns described by Gesell for smaller blocks. The youngest children could not at all estimate distance between the two base blocks of the bridge and typically the older 3-year-old child placed the base blocks together, then moved them slightly apart after finishing the bridge. Only the better coordinated children could pile the six plastic blocks used in this study; this required some staggering of juxtaposed blocks because of the unevenness of their surfaces. Most children built towers of four to five blocks spontaneously, and did attempt to add the last blocks(s) when the tower fell. Despite well

Table 9.—STEREOSCOPE: PATTERNS OF RESPONSE (Breakdown by Sex, Race, and Age)

Test	Sex		Race		Age (months)																			
	M	F	N	W	31	32	33	34	35	36	37	38	39	40	41	42	43	44	45	46	47	49	53	54
Testable:																								
Looks, reports, fusion determinable	12	14	12	14	---	---	---	1	1	1	3	1	3	2	---	2	3	3	1	2	2	1	---	--
Nontestable:																								
Looks, reports, fusion undeterminable	4	2	2	4	---	---	---	---	1	1	---	---	1	---	---	---	---	1	2	---	---	---	---	--
Looks, no reporting	5	12	6	11	---	---	---	3	---	1	1	1	4	2	---	2	---	1	---	---	1	---	---	1
No correct looking (at instrument)	6	2	3	5	---	---	---	---	---	2	2	1	---	---	---	1	1	1	---	---	---	---	---	--
No correct looking (several feet from instrument)	4	7	5	6	---	1	1	1	1	2	---	---	---	---	1	1	2	---	1	---	---	---	---	--

Table 10.—PERFORMANCE—TESTABLE AND NONTESTABLE CHILDREN (Breakdown by Sex, Race, and Age)

Test	Sex		Race		Age (months)																			
	M	F	N	W	31	32	33	34	35	36	37	38	39	40	41	42	43	44	45	46	47	49	53	54
Blocks:																								
Attempted	40	45	36	49	---	2	3	6	4	10	6	5	8	4	7	5	8	5	5	3	3	1	---	--
Testable	37	43	35	45	---	2	2	6	4	10	5	3	8	4	7	5	8	5	4	3	3	1	---	--
Nontestable	3	2	1	4	---	---	1	---	---	---	1	2	---	---	---	---	---	---	1	---	---	---	---	--
Peg bench:																								
Attempted	46	45	41	50	---	2	5	7	4	10	7	5	8	3	7	5	8	5	5	4	3	1	1	1
Testable	46	45	41	50	---	2	5	7	4	10	7	5	8	3	7	5	8	5	5	4	3	1	1	1
Nontestable	None																							
Walking lines:																								
Attempted	9	10	11	8	---	---	---	---	---	1	---	2	2	---	1	3	2	4	---	---	2	1	---	1
Testable	7	9	8	8	---	---	---	---	---	---	---	2	1	---	1	3	2	3	---	---	2	1	---	1
Nontestable	2	1	3	---	---	---	---	---	---	1	---	---	1	---	---	---	---	1	---	---	---	---	---	--
Ball playing:																								
Attempted	44	45	39	50	1	2	4	6	4	10	7	5	8	3	7	5	8	5	5	4	3	1	---	1
Testable	40	42	37	45	1	2	4	5	3	8	6	5	8	3	7	5	7	5	4	4	3	1	---	1
Nontestable	4	3	2	5	---	---	---	1	1	2	1	---	---	---	---	---	1	---	1	---	---	---	---	--
Puzzle:																								
Attempted	47	47	41	53	1	2	5	7	4	11	7	5	8	4	7	5	8	5	5	4	3	1	1	1
Testable	47	47	41	53	1	2	5	7	4	11	7	5	8	4	7	5	8	5	5	4	3	1	1	1
Nontestable	None																							

developed handedness, the most usual pattern was alternation of hands or use of both hands together in performing these tasks. The train was easily reproduced but most children failed to add an engine and placed all six blocks on the same level.

Peg bench. The peg bench activity was attempted with 91 children (table 2 and 10) and all of them were considered testable (table 1). The three children who did not attempt this test were not tested alone, and the other child being tested monopolized the game.

There tended to be three outstanding patterns of response which overlapped only slightly:

(1) Most disorganized, uncoordinated, immature. Children held the hammer with the hand pronated on the handle near its head, frequently had the hammer head on its side, and often changed hands. They banged on the bench and on the solidly placed pegs, setting these out of their holes, enjoying the noise and the flying pegs. They turned the bench to its side, banged it there, never understood the game as it was demonstrated.

(2) More organized, coordinated, and mature. Children were less destructive in other activities than the first group. They held the hammer in a preferred hand in a more usual manner with the head upright. They tended to hit the solidly placed pegs endlessly, holding these like nails, with the opposite hand, and never letting them fly off the bench. Their aim was good, for the most part. Despite reinstruction, however, these children never showed comprehension of the fact that a peg could be hit through the bench, and showed no evidence of awareness of this difference in the hole depth. This activity was particularly frustrating to

onlooking parents and older siblings, but the children did not seem to think they were missing anything.

(3) Most organized, coordinated, and mature. Children were generally chronologically older. They held the hammer in one hand and hit with a solid stroke and good aim. They recognized the game, took out all pegs and used them in turn, banging pegs into the hole and through the tunnel in the bench. They interrupted their hammering to probe the depth of the holes and pull pegs out of the exit hole.

Observation of this activity performed monocularly gave no new information, but definitely helped to corroborate suspicions based on other tests.

Walking lines. This test was attempted with 19 of the more cooperative children (tables 2 and 10). This was discontinued, however, because lines were frequently not available, and the pattern of response was such that the desired information was not forthcoming. Also, this test added no information to that derived from ball playing.

Those 16 called testable (table 1) were able with both eyes and each eye to follow the instruction to walk a straight line; but the typical response was a running walk with one foot to each side of the line, and the rapidity of movement made it impossible to detect deviation. These young children were not coordinated enough to walk precisely heel to toe; the few who could be persuaded to do this needed balance steps to each side. The three children called nontestable did not even begin to walk when this test was done.

The mask did not seem to make a difference; once a roughly straight line had been walked with the two eyes, the testable children reproduced the performance with each eye.

Ball playing. This test was attempted with 89 children (tables 2 and 10) to whom the ball was given to initiate play. The five children who did not get a chance at the ball were not tested alone. Of the 89, 82 were considered testable (table 1) and the 7 children who never held and released the ball in any way were nontestable.

In general, this was a well accepted and informative test. Usually the game was played with the examiner, but it sometimes helped to have another child participate, especially in those situations where more than one child was present. With this particular ball and the short distances involved most children were able to do quite well. This "test" was a treat for many children who are usually forbidden to play ball in their homes.

Younger children tended to catch with eyes closed, mouth open, and two hands. This advanced to catching with the whole body; and

Table 11.—EYE DOMINANCE—TESTABLE AND NONTESTABLE CHILDREN (Breakdown by Sex, Race, and Age)

	Sex		Race		Age (months)																			
	M	F	N	W	31	32	33	34	35	36	37	38	39	40	41	42	43	44	45	46	47	49	53	54
Attempted	47	47	41	53	1	2	5	7	4	11	7	5	8	4	7	5	8	5	5	4	3	1	1	1
Testable	26	31	23	34	0	2	1	5	0	7	1	3	4	3	4	3	8	4	4	3	3	1	0	1
Near eye dominance	10	14	8	16	---	---	1	4	---	5	---	3	2	---	2	1	4	1	---	---	1	---	---	--
Clear eye dominance	16	17	15	18	---	2	---	1	---	2	1	---	2	3	2	2	4	3	4	3	2	1	---	1
Nontestable (no eye preference)	21	16	18	19	1	0	4	2	4	4	6	2	4	1	3	2	0	1	1	1	0	0	1	0

finally, in the best coordinated, to spotting the ball and moving only the arms to reach it. All the children could roll the ball although many had never done this and preferred the noiser and more dynamic bouncing. Throwing underhand was the method used by all except the most coordinated who were able to throw overhand as well.

It was easy to detect differences in performance created by the mask, i.e. binocular versus uniocular performance. This made a significant difference in most children—a fact which was taken to indicate binocularity as the preferred mode of seeing. The tasks were so simple, though, that adaptation to uniocularity took place rapidly, usually in a minute. The color and size of the ball made it an easy target to find even when it was purposely thrown off course.

Ball kicking was attempted with 26 children and was successful in 25; only 1 who was nontestable on all procedures involving the ball refused to kick at all. Repeated kicks yielded reproducible results in almost all cases; it was assumed that the few who changed feet to kick might not yet have established foot dominance.

Puzzle. The puzzle was attempted with 93 children (tables 2 and 10) to whom it was demonstrated, and all of them could be considered testable (table 1). Even children tested together made certain they each had a turn at this extremely appealing toy, and otherwise nontestable children enjoyed walking away with this and doing some work on it.

As with the peg bench there were definite patterns of response:

(1) Least mature and coordinated. Children placed pieces haphazardly over the spaces in the board, turned pieces upside down, and paid no attention to which piece might fit which position. They hammered on the piece with a fist or pushed and shoved to get the piece into the board, but never turned or lifted and replaced.

(2) More mature and coordinated. Most of the children who had not done puzzles previously used trial and error first but got each piece into its right position after much maneuvering, usually taking between 3 and 10 minutes. Turning the board 180 degrees often completely destroyed their learning of the task, i.e. the perception of the board and shapes was very concrete and dependent upon the single direction in which it had been tried.

(3) Most mature and coordinated. Children who were especially capable and all those who had been to nursery school (regardless of general capability and testability) were able to complete the puzzle with minimal errors on the first trial in less than 1 minute. Also most of these children made no additional mistakes when the board was turned 180 degrees.

This test was not informative in proportion to the time it consumed. It was very useful as a means of gaining cooperation initially, but it seemed pointless to prolong this activity by using occluders since the fumblers continued to fumble and the better performers were able enough with one eye to do well.

Dominance

Eye dominance tests were attempted with all 94 children; everyone was asked to sight through at least one of three devices— the cardboard, tube, or lorgnette. Observations of handedness were made in all cases. Children who inspected the cardboard devices but never sighted, and those who used fingers, mouth, or nose rather than eyes to "sight" were called nontestable (tables 2 and 11); there were 37 such children, with a mean age of 38 months, who either had not established or did not demonstrate any eye preference with this test. The other 57 children called testable (tables 1, 2, and 11) showed some eye preference; 24 children with a mean age of 39 months had not established a dominant eye but seemed definitely to prefer one over the other; and 33 children with a mean age of 42 months had clearly established a dominant eye.

In general, the lorgnette was preferred to the cardboard and the cardboard to the tube. Those children who had not clearly established dominance would use the favored eye when holding the cardboard with both hands or the hand of that side, and would use the nose or even the opposite eye when using the opposite

Table 12.—PATTERNS OF DOMINANCE (Breakdown by Sex, Race, and Age)

Pattern	Sex		Race		Age (months)																			
	M	F	N	W	31	32	33	34	35	36	37	38	39	40	41	42	43	44	45	46	47	49	53	54
Nearly established dominance:																								
R eye, R hand (15)	4	11	5	10	---	---	---	4	---	4	---	2	1	---	---	---	2	1	---	---	1	---	---	--
L eye, L hand (6)	3	3	2	4	---	---	1	---	---	1	---	1	1	---	1	---	1	---	---	---	---	---	---	--
R eye, L hand (1)	1	0	0	1	---	---	---	---	---	---	---	---	---	---	---	---	1	---	---	---	---	---	---	--
L eye, R hand (2)	2	0	1	1	---	---	---	---	---	---	---	---	---	---	1	1	---	---	---	---	---	---	---	--
Clearly established dominance:																								
R eye, R hand (21)	12	9	9	12	---	1	---	1	---	1	---	---	2	1	1	---	3	2	3	2	2	1	---	1
L eye, L hand (2)	1	1	1	1	---	---	---	---	---	---	---	---	---	1	---	1	---	---	---	---	---	---	---	--
R eye, L hand (1)	0	1	1	0	---	1	---	---	---	---	---	---	---	---	---	---	---	---	---	---	---	---	---	--
L eye, R hand (9)	3	6	4	5	---	---	---	---	---	1	1	---	---	1	1	1	1	1	1	1	---	---	---	--

hand. Perhaps because of naivete on the part of subjects and examiner, these findings seemed very reproducible.

Based on the observations of handedness and determinations of eyedness, table 12 shows how many children preferred the same hand and eye, i.e. were "straight" dominant, and how many showed preference for an eye contralateral to the hand, i.e. were "mixed" dominant. Of the 24 with nearly established eye dominance, 21 (15 right and 6 left) preferred the eye on the same side as the favored hand (and foot where this was tested), while the other 3 (1 right eyed, left handed, and 2 left eyed, right handed) showed eye preference opposite to hand preference. Of the 33 with clearly established eye preference, 23 (21 right and 2 left) showed "straight" dominance and 10 (1 right eyed, left handed, 9 left eyed, right handed) demonstrated "mixed" dominance.

Table 13.—COLOR—TESTABLE AND NONTESTABLE CHILDREN (Breakdown by Sex, Race, Age, and Type of Response)

Response	Sex		Race		Age (months)																			
	M	F	N	W	31	32	33	34	35	36	37	38	39	40	41	42	43	44	45	46	47	49	53	54
Attempted	42	42	34	50	1	2	4	7	3	10	6	5	8	4	7	4	8	3	5	3	1	---	---	--
Testable	16	20	18	18	0	2	0	2	0	3	1	4	3	1	5	3	6	2	2	1	0	---	---	--
Matches only	4	7	5	6	---	2	---	1	---	---	---	---	2	---	3	---	2	1	---	---	---	---	---	--
Matches, knows names, but cannot apply them	5	6	5	6	---	---	---	1	---	1	1	2	1	1	2	---	2	---	---	---	---	---	---	--
Names and matches	4	7	6	5	---	---	---	---	---	1	---	2	---	---	---	3	2	1	2	---	---	---	---	--
Attended nursery school	3	4	3	4	---	---	---	---	---	---	---	---	1	---	---	1	3	---	1	---	1	---	---	1
Nontestable	26	22	16	32	1	0	4	5	3	7	5	1	5	3	2	1	2	1	3	2	1	---	---	--

Foot dominance was noted in 25 of 26 children who were asked to kick the ball. Use of one foot only was less common than use of one hand. This finding was considered when determining sidedness. Since this was not a systematic test, however, the findings were much less important than observations of handedness.

Color

Color awareness was looked for, i.e. this test category was attempted, in 84 children. No specific observation of color sense was made in 10 children (tables 2 and 13) who did not play with colored toys long enough or quietly enough to have made this feasible. The 36 children called testable (table 1) showed various degrees of color awareness which are summarized in table 13. The other 48, nontestable children, showed varying degrees of color awareness which are summarized in table 13.

Colors, like numbers and the alphabet, were frequently learned by rote either from an older sibling or a parent anxiously attempting to climb the educational ladder. The ability to name colors varied with such previous drill rather than with age, and it is noteworthy that at least half of the children who had learned color names still could not correctly use them at this age. These were often the same families where mothers insisted children count and the result was a duly recited "one, six, seven, thirteen, nineteen years old!"

Findings on questionnaire

The questionnaire was attempted with all and answered satisfactorily in 90 cases, those considered testable in table 2. The four unsatisfactory responses were the only situations where a parent was not the informant; two were a foster mother, one a grandmother, and one an aunt. The parents in many cases were probably not more reliable than these other informants, but they at least attempted to answer the questions.

There were 19 children (table 14) whose mothers reported symptoms or signs possibly indicative of eye problems. Fifteen of these

Table 14.—TESTABILITY OF 19 CHILDREN WITH POSSIBLE EYE PROBLEM BY HISTORY (Breakdown by Sex, Race, and Age)

Testability	Total No.	Sex		Race		Age (months)																			
		M	F	N	W	31	32	33	34	35	36	37	38	39	40	41	42	43	44	45	46	47	49	53	54
Nontestable	8	5	3	3	5	----	----	----	----	2	1	1	1	2	----	----	----	----	----	----	----	----	----	----	----
Testable, pass	3	3	0	2	1	----	----	----	----	----	2	----	----	----	----	----	----	1	----	----	----	----	----	----	----
Testable, fail	8	5	3	3	5	----	----	----	----	----	----	----	----	----	----	1	1	1	1	2	----	----	1	----	1
Total with signs and symptoms	19	13	6	8	11	----	----	----	----	2	3	1	1	2	----	1	1	2	1	2	----	----	1	----	1

nineteen had at some time had a turned eye. Intermittent turning in the first 3 months of life was not considered in this tabulation. Occasional turning of one eye, most noticeable with fatigue and fever, was the most frequent report. Two twin girls had eyes which, according to the mother, "converge for 15 minutes every morning on awakening, a family trait." Several mothers reported they had not noticed any deviation but a neighbor had seen the eye turn. Most of the 15 said this turning had become more evident or had had its onset in the last year, i.e. in the third or fourth year of the child's life. Only one child had constant strabismus and this was first noticed several months before examination. The four children without turned eyes had torticollis, clumsiness with and without excessive blinking, tearing and "floating out" of an eye. In 15 of the 19 children with suspicious histories, there was some family history of eye problems and heightened awareness and interest in the child's eyes; tables 14 and 15 therefore overlap in many cases. Testability of these children used in compiling table 14 (and 15 and 16) was overall testability, but primarily testability on differential visual acuity testing, i.e. on tests which detect low vision and possible amblyopia.

A total of 57 children (table 15) had a positive family history. A variety of visual problems was reported: 17 children had a total of 20 siblings with strabismus (all but 4 not detected until school vision tests). Six parents and six aunts, uncles, or cousins had strabismus as well. Longstanding refractive errors existed in 31 parents; and 29 siblings (of 25 children) wore glasses—presumably 18 of these aiding the correction of stabismus. Other severe visual problems—amblyopia, cataracts, trauma—were reported for five parents and four siblings.

Developmental histories could not be collected. Except in cases of flagrant slow development, e.g. lack of language, all mothers claimed this tested child was faster than his siblings! Developmental milestones were averages of all the children in the family rather than individual steps, and the time of toilet training tended to be the primary individualized fact of development retained by most mothers.

Table 15.—TESTABILITY OF 57 CHILDREN WITH POSITIVE FAMILY HISTORY OF EYE PROBLEMS (Breakdown by Sex, Race, and Age)

Testability	Total No.	Sex		Race		Age (months)																			
		M	F	N	W	31	32	33	34	35	36	37	38	39	40	41	42	43	44	45	46	47	49	53	54
Nontestable	25	11	14	9	16	1	----	2	4	2	4	1	2	3	----	2	----	1	----	1	1	----	----	1	----
Testable, pass	25	12	13	13	12	----	1	----	2	----	4	2	1	----	1	2	3	4	1	1	2	1	----	----	----
Testable, fail	7	5	2	2	5	----	1	----	----	----	----	----	----	----	1	1	1	----	----	1	----	----	1	----	1
Total with positive family history	57	28	29	24	33	1	2	2	6	2	8	3	3	3	2	5	4	5	1	3	3	1	1	1	1

Table 16.—TESTABILITY OF 10 PREMATURE CHILDREN (Breakdown by Sex, Race, and Age)

Testability	Total No.	Sex		Race		Age (months)																			
		M	F	N	W	31	32	33	34	35	36	37	38	39	40	41	42	43	44	45	46	47	49	53	54
Nontestable	5	2	3	1	4	----	----	1	2	1	----	----	----	----	----	----	----	1	----	----	----	----	----	----	----
Testable, pass	5	2	3	4	1	----	----	----	1	----	----	----	1	1	----	----	----	----	1	1	----	----	----	----	----
Testable, fail	0	0	0	0	0	----	----	----	----	----	----	----	----	----	----	----	----	----	----	----	----	----	----	----	----
Total premature	10	4	6	5	5	----	----	1	3	1	----	----	1	1	----	----	----	1	1	1	----	----	----	----	----

Ten of the 94 children (11 percent compared to the national average 7 percent) had been premature by birthweight (table 16); five had required oxygen and prolonged hospitalization. Four of five nontestable children had been severely ill during infancy—two with meningitis, one with some hemorrhagic episode, and one with neonatal convulsions.

There were two children, not prematures, who had also had prolonged illnesses requiring hospitalization: a girl with Vitamin D resistant rickets, and one with jaundice and fever of unknown origin; one was testable (table 1), and the other, a twin, was nontestable primarily because of environmental confusion. Many of the children in the study had spent short times in the hospital for minor illnesses and operations, but the exact frequency of such occurrences is difficult to state; the mothers were surprisingly vague about such things, tended to confuse their children.

Composite test findings: Testability and nontestability

Visual acuity

Visual acuity tests are compared in figure 3; while this comparison is observed, the difference in the tests themselves and the criteria of testability should be recalled (table 1). Each bar represents the number of children of that particular age with whom the test was attempted; the area shaded represents the number testable with each visual acuity measurement. Testable for all five sets of bar graphs does not mean actual measurements were made but rather that acuity ***might*** be measured with the test in question. These values might be overestimates; children called testable for the purposes of this compilation would not necessarily be testable if a formal test of the same type was administered. The values plotted in figure 3 called "testable" really represent the ability of the child to communicate his understanding of the particular visual acuity test—without an occluder, and without any distance from the examiner.

The five bar graphs on figure 3 were plotted from the findings on the Stycar miniature toy test for two eyes, the Stycar matching letters, the hand direction test, the picture naming, and the opticokinetic nystagmus.

The top graph representing the miniature toy test is noteworthy for the high ratio of testable children even for the younger children tested, and for its overall high testability compared to the other four tests. The Stycar letter test and the OKN seem to show less of a definite increase in the ratio of testable children with age than do the picture naming and direction, indicating tests. Picture naming shows high levels of testability but not as high as the toy test. Ability to perform on picture and direction tests seems definitely age dependent, and ability to perform on Stycar letters seems less obviously age dependent. However, it should be noted that 17 of the 26 children who were testable (table 1) on the Stycar letters were older than 42 months (tables 2 and 3). OKN testability seems less age dependent or at least not dependent on development which normally occurs during the range of ages covered in this study; the percentage of testable children at many of the younger ages is the same as at the higher extreme.

The Stycar letter test and the direction tests are somewhat more comparable to each other than to the others since they seemed to require more abstract thought from the child. The results of the direction tests were better in general, but the ability to match letters and the ability to indicate directions did not necessarily overlap. It can be seen from table 17 that 17 children could do both, but 25 children could indicate directions with the hand and not match letters while only 9 could match letters and not indicate directions sufficiently well to be considered testable (tables 1 and 2).

There was only one child who was not completely testable with miniature toys (testable with two eyes but not with each eye) and was testable on any of the other visual acuity tests; this girl had good direction indicating ability. The nonspeaking children, who were nontestable on picture naming, were usually also nontestable on Stycar letters and direction tests; several were testable with miniature toys and one could indicate directions.

Those children found testable on the OKN test (tables 1, 2, and 7) were not the same children as those considered testable on other acuity tests; the children in whom OKN could not be elicited were often testable with other methods (table 18).

If an objective measure of acuity like OKN could be refined, and performed without an obvious occluder, some of the presently nontestable children might thus be tested effectively. A combination of this and the miniature toy test, for instance, yielded a 17 percent

Table 17.—COMPARISON OF ABILITY OF MATCH LETTERS AND DIRECTIONS (Breakdown by Sex, Race, and Age)

	Sex		Race		Age (months)																			
	M	F	N	W	31	32	33	34	35	36	37	38	39	40	41	42	43	44	45	46	47	49	53	54
Matches letters and indicates directions (17)	10	7	9	8	---	---	---	---	1	1	---	1	1	---	1	1	3	1	2	1	2	1	---	1
Matches letters and does not indicate directions (9)	4	5	2	7	---	---	---	---	---	1	---	---	1	---	---	2	2	---	---	2	1	---	---	--
Indicates directions and does not match letters (25)	11	14	11	14	---	---	---	---	---	2	2	1	2	2	3	2	5	2	1	1	1	---	1	--

FIGURE 3: COMPARATIVE TESTABILITY BY AGE FOR VARIOUS VISUAL ACUITY TESTS

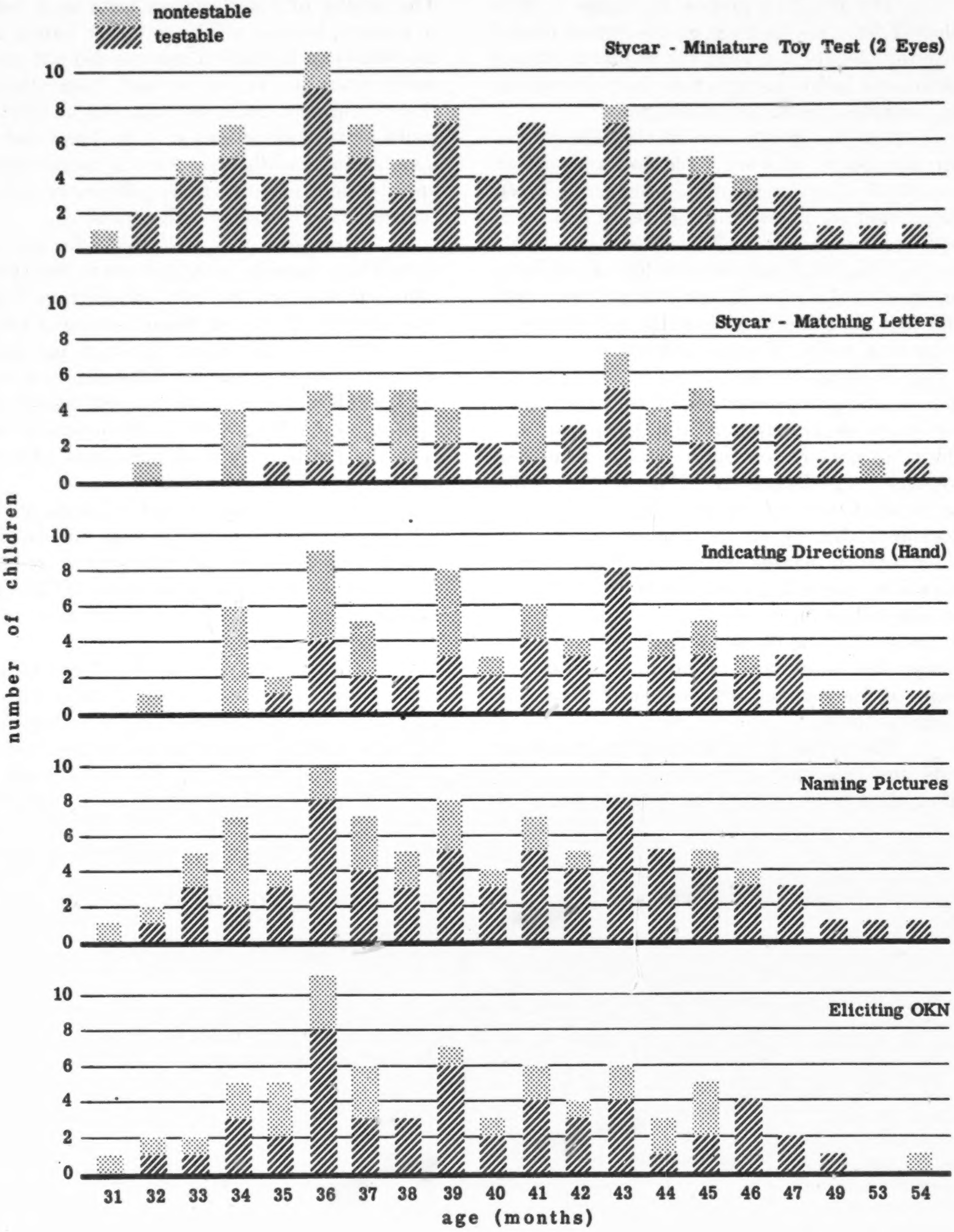


Table 18.—OKN AND MINIATURE TOYS—COMPOSITE TESTABILITY (Breakdown by Sex, Race, and Age)

Testability pattern	Total No.	Sex		Race		Age (months)																			
		M	F	N	W	31	32	33	34	35	36	37	38	39	40	41	42	43	44	45	46	47	49	53	54
Testable, OKN and testable, miniature toys (1 eye)	34	20	14	18	16	----	1	----	1	1	6	2	3	3	1	1	2	3	1	2	4	2	1	----	----
Testable, OKN and nontestable, miniature toys	16	3	13	6	10	----	----	1	2	1	2	1	----	3	1	3	1	1	----	----	----	----	----	----	----
Nontestable, OKN and testable, miniature toys	14	7	7	7	7	----	1	----	----	1	1	1	1	1	1	2	----	1	2	2	----	----	----	----	----
Nontestable, OKN and nontestable, miniature toys	13	8	5	2	11	1	----	1	1	2	2	2	----	1	----	----	----	1	----	1	1	----	----	----	----

nontestable rate compared to the 35 percent nontestable with either test alone.

Muscle balance

Testability on muscle balance tests did not correlate well with testability on other tests. The children who cooperated with these tests so that they could be attempted had all been testable with at least the miniature toy acuity test. The response to the stereoscope made 26 children testable (tables 1, 2, and 9), and these were all children who were testable on a number of acuity tests and did especially well on performance tests. Children who looked into the stereoscope and did not speak were slightly less testable on acuity and performance tests in general, but were *not* the nonspeaking children found on picture naming tests. Deviation of one eye at the near point of convergence has been used as an indication of eye dominance, but a comparison of the deviating eye and dominant eye based on sighting tests (table 19) did not show such a relationship.

Performance

Performance tasks were rated all together for summary purposes (see table 20). The ratings—excellent, very good, good, fair, and poor—could be applied because the ability to perform one task well was directly related to the ability to perform other tasks involving the use of forms and space. Unusual facility at one task usually meant that the child had had previous experience with the particular puzzle used, and in these cases, poorer performances were weighted more heavily in the final rating. In general, older children received higher ratings. The 12 children rated excellent on the basis of an expected 36 month norm (based on Gesell) had a mean age of 43 months; the 7 rated very good had a mean age of 40 months; the 26 rated good had a mean age of 39 months; the 24 rated fair had a mean age of 39 months; and the 25 rated poor had a mean age of 38 months. Females rated higher than males.

This summary rating on performance tasks expresses motor coordination and the child's ability to act upon his perceptions of

Table 19.—NEARPOINT OF CONVERGENCE DEVIATING EYE vs. EYE DOMINANCE BY SIGHTING (Breakdown by Sex, Race, and Age)

	Total	Sex		Race		Age (months)																		
		M	F	N	W	31	32	33	34	35	36	37	38	39	40	41	42	43	44	45	46	47	53	54
Deviation, dominance:																								
Deviating eye, plus dominant eye	24	12	12	8	16	---	1	---	2	---	1	1	1	4	1	1	2	2	---	3	3	2	---	---
Deviating eye equals dominant eye	15	5	10	10	5	---	---	---	---	---	2	2	---	1	1	1	1	3	2	1	---	---	---	---
Deviating eye, no dominant eye established	19	8	11	5	14	1	---	---	2	2	3	---	3	1	2	1	1	2	1	---	---	---	---	---
Deviating eye "L"	13	6	7	4	9	1	---	---	1	1	2	---	2	1	1	1	1	1	1	---	---	---	---	---
Deviating eye "R"	2	---	2	---	2	---	---	---	1	---	---	---	---	---	---	---	---	1	---	---	---	---	---	---
Deviating eye, alternates	4	2	2	1	3	---	---	---	---	1	1	---	1	---	---	---	---	---	---	---	---	---	---	---
Neither deviates	9	5	4	6	3	---	1	---	---	---	2	---	---	1	---	1	1	1	2	---	---	---	---	---

space. The ratings were roughly correlated with overall testability, but there were children who were more testable on acuity tests and others who were uniquely testable and capable on these more active tests.

There was an overlap between superior performance ratings and ability to indicate directions; this correspondence was not so striking for other tests with limited testability. Twenty-seven of the children who were testable on the hand direction test (tables 1, 2, and 6) received ratings of good, very good, or excellent in overall performance. However, 15 others were not considered so well coordinated; and 18 with similar superior performance (including 1 excellent) ratings failed to indicate directions adequately.

Dominance

There is a striking relationship between the lack of dominance and overall nontestability particularly nontestability on differential acuity tests (table 21): of the 37 children with no eye dominance demonstrated, 33 were recommended for retests, usually because immaturity and occluder rejection had prevented complete appraisal of the vision of each eye. Of the 57 children who showed some eye preference, 18 were recommended for follow-up, but only 2 of these 18 were considered nontestable because of immaturity; the others had been testable and received this recommendation for other reasons, e.g. a history of strabismus, question of amblyopia, or poor environment for testing.

Color

Ability to match or name colors did not seem causally related to testability. There was a general relationship in that children who knew colors were older and more testable for that reason (tables 1, 2, and 13). Inability to show recognition of colors did not seem to specifically decrease performance on other tests which contained colored materials but did not depend upon their color. The children who had been to nursery school did better at this (table 13), perhaps because of a more meaningful experience involving colors. However, nursery children also tended to be somewhat older

Table 20.—PERFORMANCE TESTS: COMPOSITE RATINGS (Breakdown by Sex, Race, and Age)

Rating	Total	Sex		Race		Mean Age	Age (months)																			
		M	F	N	W		31	32	33	34	35	36	37	38	39	40	41	42	43	44	45	46	47	49	53	54
Excellent	12	4	8	5	7	43	---	---	---	---	---	1	---	---	1	---	---	3	2	1	1	---	3	---	---	---
Very Good	7	3	4	3	4	40	---	---	---	---	1	2	---	---	---	---	1	---	1	1	---	1	---	---	---	---
Good	26	14	12	11	15	39	---	---	2	2	---	3	2	2	2	2	3	---	3	2	1	2	---	---	---	---
Fair	24	10	14	12	12	39	---	1	1	3	---	3	1	1	4	1	1	1	1	1	2	1	---	---	---	---
Poor	25	16	9	10	15	38	1	1	2	2	3	2	4	2	1	1	2	1	1	---	1	---	---	1	---	---

Table 21.—EYE PREFERENCE AS AN INDICATION OF TESTABILITY (Breakdown by Sex, Race, and Age)

	Total	Sex		Race		Age (months)																			
		M	F	N	W	31	32	33	34	35	36	37	38	39	40	41	42	43	44	45	46	47	49	53	54
No eye preference nontestable	33	17	16	15	18	1	----	4	2	3	3	5	2	4	1	3	1	----	1	1	1	----	----	----	1
No eye preference testable	4	4	0	3	1	----	----	----	----	1	1	1	----	----	----	----	1	----	----	----	----	----	----	----	----
Eye preference nontestable	2	1	1	0	2	----	1	----	----	----	----	----	----	----	----	----	----	1	----	----	----	----	----	----	----
Eye preference testable; follow-up recommended	16	11	5	9	7	----	----	1	----	----	3	----	----	1	2	2	1	1	2	1	----	----	1	----	1
Eye preference testable; no followup	39	14	25	18	21	----	1	----	3	1	3	2	2	5	2	2	2	5	3	2	3	3	----	----	----

(mean 45 months) than the whole group tested (mean 39 months).

Composite test findings: Passing and failing

Although children could be considered testable or nontestable on each test, there were only some tests on which it was appropriate to rate them passing or failing. This is because many of the tests were not formalized to the extent of examining a visual ability; the goal of these, as stated previously, was to tell how children would respond to a test of this type if it were an actual examination. Some tests were used to examine visual functions, and children who were testable either passed or failed these tests. Table 22 summarizes the tests and defines the passing criterion for each test where this is applicable.

Visual acuity—Stycar

Matching letters. This test looked for an ability which was then used in the near and distant letter tests to measure visual acuity. Children who had the ability were testable (table 1), but did not pass or fail this particular test (table 22).

Near letter test. Of the 22 testable children (tables 1, 2, and 3) only 20 accepted the occluder for this test and could thus be considered as passing or failing (tables 22 and 23). The three children who failed the near letter test did not have equal near visual acuity in their two eyes. Of the three failures (table 24) two failed distant visual acuity tests and one of these two also failed the stereoscope and performance tests. One child failed no other visual acuity test; his attention had been adequate but less than optimal for this test, but the only other area he failed was the color tests.

Distant letter test. Of the 10 testable children (tables 1, 2, and 3), 4 had failed the distant letter test (table 23). One of these also failed the near letter and miniature toy

Table 22.—PASSING CRITERIA FOR TESTS

Test	*Passing is defined as*
Visual acuity—Stycar:	
Matching letters	
Near letter test	N6 in each eye and equal acuity in 2 eyes.
Distant letter test	6/9 or better in each eye and equal acuity in 2 eyes.
Miniature toy test	Matching all toys (except small fork) with each eye and the same toys (equal acuity) in both eyes.
Visual acuity—Naming pictures and toys	
Pictures	20/40 or better in each eye and equal acuity in 2 eyes (only applicable when actual measurement made).
Toys	
Visual acuity—Indicating directions	
Drawing	
Hand	
E	
Visual Acuity Eliciting	
OKN	Equal nystagmus elicited when each eye stimulated.
Muscle Balance:	
NPC and penlight following	NPC less than 5 cm. from nose; parallel extra ocular movements.
Cover test (and Hirshberg).	No horizontal or vertical deviation under cover or inequalities in corneal reflection.
Red Glass Test	Reporting single red light.
Stereoscope	Reporting fused picture (combination of right and left eyes).
Performance	Excellent, very good, or good combined ratings (table 19).
Blocks	
Peg bench	When done with occluder, no consistent deviation to one side, or inequality of monocular performance.
Walking lines	
Ball	
Puzzle	
Dominance	
Color	Consistent correct naming or matching colors.

Table 23.—TOTAL TESTABLE CHILDREN PASSING AND FAILING EACH TEST AND QUESTIONNAIRE

Test	No. testable	Passing		Failing	
		Number	Percent	Number	Percent
Visual acuity-Stycar:					
Matching letters	26	--------	--------	--------	--------
Near letter test	(22*) 20	17	85	3	15
Distant letter test	10	6	60	4	40
Miniature toy test	60	45	75	15	25
Visual acuity—Naming pictures and toys:					
Pictures	(67*) 2	1	50	1	50
Toys	29	--------	--------	--------	--------
Visual acuity—Indicating directions:					
Drawing	61	--------	--------	--------	--------
Hand	42	--------	--------	--------	--------
E	21	--------	--------	--------	--------
Visual acuity eliciting OKN	50	47	94	3	6
Muscle balance:					
NPC and penlight following	67	62	92	5	7
Cover test (and Hirshberg)	32	26	81	6	19
Red glass test	2	1	50	1	50
Stereoscope	26	23	88	3	12
Performance	94	(45*) 6	(48*) 6	(49*) 88	(52*) 94
Blocks	80	--------	--------	--------	--------
Peg bench	91	--------	--------	--------	--------
Walking lines	16	--------	--------	--------	--------
Ball	82	--------	--------	--------	--------
Puzzle	94	--------	--------	--------	--------
Dominance	57	--------	--------	--------	--------
Color	36	33	92	3	8

*See text for explanation of numbers in parentheses.

tests (table 24) and his failure on this test was caused by a wide disparity in visual acuity between the two eyes. The other three failures on this test passed other tests. One child had 6/9 visual acuity in one eye tested, refused the occluder so the second eye was not tested; on the toy test she accepted the occluder and the second eye proved as good as the first. The other 2 "failures" had a difference of one line between the eyes although both eyes had good vision (6/9 and 6/6, and 6/6 and 6/4); these children were considered failures for the tabulation but not considered worthy of followup. One of these children saw one fewer toy with the "worse" eye despite its normal acuity and the other saw one more toy with the eye that tested worse with the letters. Both of these children had a strong family history of eye disorder; each had a parent with unilateral blindness.

Miniature toy test. Of the 60 children who could be tested with each eye alone (tables 1, 2, and 3), 15 failed (table 23) this test when all toys (except small fork) or at least the small spoon and knife had to be identified in order to pass (table 22). Of the 15 failures, 10 failed other tests as well including 1 who failed the cover but had not been testable on any other tests which could be failed. One child failed

TABLE 24: FAILURES ON TESTS AND QUESTIONNAIRE BY AGE

▨ Indicates failure.

Blank space means nontestable or pass; only when of particular interest, a pass is noted.

Age (Months)	Near Letters	Distant Letters	Miniature Toys	Pictures	OKN	Penlight	Cover (Hirschberg)	Red glass	Stereoscope	Performance	Color	Questionnaire		Follow-up Recommendation
32			▨				▨					▨	*F. Hx. brother w/squint	retest
33			▨										Nontestable	retest
34			▨									▨	Premature twin	retest
34			Pass			▨						▨	Premature & meningitis	retest
36			▨		▨		▨					▨	F. Hx. sister w/myopia	retest
36			Pass				▨				▨	▨	F. Hx. ; cleft palate	retest
37			Pass			▨						▨	Premature	retest
37						▨				▨		▨	**P. Hx. squint, 2 siblings	retest
38			Pass			▨						▨	F. Hx. squint, 2 siblings	retest
40			Pass			▨						▨	F. Hx. squint	retest
41			Pass							▨				nursery
42		▨	▨									▨	F. Hx. squint & amblyopia	***none
42			▨											retest
42			▨				▨			▨	▨	▨	P. Hx. squint	refer
42		▨	▨									▨	F. Hx.	***none
43	▨		▨						▨	▨				retest
43			▨							▨		▨	P. Hx. squint	retest
44			▨	▨								▨	P. Hx. squint	retest
44			Pass									▨	Premature	***none
45			▨		▨			▨	▨			▨	P. Hx. clumsiness	refer
45			▨		▨		▨		▨				P. Hx. squint	retest
46	▨		Pass								▨			***none
46			Pass							▨				nursery
47		▨	Pass											***none
49			▨									▨	P. Hx. squint	retest
54	▨	▨	▨				▨					▨	P. Hx. clumsiness	refer
Totals	3	4	15	1	3	5	6	1	3	6	3	18		

*F. Hx. = Family History **P. Hx. = Personal History ***See text for explanation the questionnaire but no test; four failed only the toy test (tables 24 and 25).

The patterns of failure were inability to match or name the same toys with each eye and inability to see the smaller toys with either eye. Children who recognized all toys with each eye but could not distinguish the small fork from the small spoon with either eye were passed; this distinction was considered beyond expected visual acuity for the age, approximately 6/9 or 20/30. Children who recognized all toys with one eye, however, were failed if they did not do so with their other eye—even if it was just a difference of one small utensil. Table 25 shows the distribution of children who failed the miniature toy test.

Visual acuity—Naming pictures and toys

Pictures. Only 2 of the 67 children were asked to name pictures at a distance with each eye occluded, both using the Osterberg chart. One child passed (tables 22 and 23) and the other failed. The child who failed also failed the miniature toy test because he did not differentiate small utensils with either eye; he had been shown the miniature Osterberg chart and was able to name many more pictures on this than the large chart placed 10 feet away. On the questionnaire, this child's mother had reported that he tended to hold things close to his face and sit close to the television set.

Toys. Passing and failing do not apply to this test as given.

Visual acuity—Indicating directions

Drawing, Hand, "E." None of these tests was given as a formal test for distant visual acuity; therefore, passing and failing criteria are not applicable.

Visual acuity—Eliciting OKN

Of the 50 testable children, 3 consistently showed inequality of response which

Table 25.—FAILURES ON MINIATURE TOY TEST (Breakdown by Sex, Race, Age and Other Test Failure)

	Sex		Race		Age (months)																			
	M	F	N	W	31	32	33	34	35	36	37	38	39	40	41	42	43	44	45	46	47	49	53	54
Failures	10	5	5	10	---	1	1	1	---	2	---	---	---	---	---	4	2	1	2	---	---	---	---	1
Failed only toys	2	2	2	2	---	---	1	1	---	1	---	---	---	---	---	1	---	---	---	---	---	---	---	---
Also failed	8	3	3	8	---	1	---	---	---	1	---	---	---	---	---	3	2	1	2	---	---	---	---	1
Near letters	2	---	1	1	---	---	---	---	---	---	---	---	---	---	---	---	1	---	---	---	---	---	---	1
Distant letters	1	1	1	1	---	---	---	---	---	---	---	---	---	---	---	1	---	---	---	---	---	---	---	1
Picture naming	1	---	---	1	---	---	---	---	---	---	---	---	---	---	---	---	---	1	---	---	---	---	---	---
OKN	1	---	---	1	---	---	---	---	---	1	---	---	---	---	---	---	---	---	---	---	---	---	---	---
NPC, penlight	---	---	---	---	---	---	---	---	---	---	---	---	---	---	---	---	---	---	---	---	---	---	---	---
Cover	4	---	1	3	---	1	---	---	---	1	---	---	---	---	---	1	---	---	1	---	---	---	---	---
Red glass	---	1	1	---	---	---	---	---	---	---	---	---	---	---	---	---	---	---	1	---	---	---	---	---
Stereoscope	2	1	2	1	---	---	---	---	---	---	---	---	---	---	---	1	1	---	2	---	---	---	---	---
Performance	2	1	---	3	---	---	---	---	---	---	---	---	---	---	---	1	2	---	---	---	---	---	---	---
History	2	---	---	2	---	---	---	---	---	---	---	---	---	---	---	2	---	---	---	---	---	---	---	---

might be considered failure (tables 22 and 23). Children who responded with nystagmus in one direction but not at all in the other were considered nontestable because this inequality seemed attributable to poor attention. These three failures, however, repeatedly showed qualitatively different nystagmus in each direction usually a slower less smooth nystagmus of greater amplitude in one direction than in the other. Two of the three failures showed inequality of vision on several other tests (tables 24 and 25). The other one was testable and had equal vision on the minature toy test.

Muscle balance

Penlight following and NPC. The five children who failed this test (table 23) did so because of apparent unparallelism during movement of the eyes. This impression was very subjective and was always considered in conjunction with other tests before requesting followup; four of the five children could be considered questionnaire failures but failed no other test.

NPC of 5 cm. was found in three children and another eight had an NPC of 4 cm. Since none had NPC greater than 5 cm., there were no failures on this basis (table 22).

Cover test (Hirshberg). The observation of corneal reflections or Hirshberg test was used together with the cover in deciding failures for this test (table 22). There were six such failures (table 23); one failed only this test (besides color test which was unrelated) and had a positive family history and five others also failed at least the miniature toy test (table 25).

Red glass test. Of the two children who were testable (table 1), one failed (tables 22 and 23); she gave an answer which indicated suppression of the image of one eye and was consistent with the findings on other tests, the miniature toys and stereoscope (tables 24 and 25).

Stereoscope. Of the 26 testable children (tables 12 and 9), 3 indicated by their answers that they suppressed one image. All three also failed the minature toy test (tables 24 and 25); and each one failed a single additional test: the cover, near letter, and red glass.

Performance

When overall ratings of performance (table 19) are used, 49 children who received fair and poor ratings might be considered failures. These numbers appear in parentheses on table 23. The failure is in relation to the 36 month expected performance. This population tended to run about 6 months slower than Gesell's "normals;" some tasks were exactly the same as anticipated, e.g. tricycle riding and feeding of self were things all children in this study could do, but other tasks, particuarly tested ones, ran behind expectations.

The six children considered failures for this tabulation wore occluders for at least one of the performance tasks (ball, line, or peg bench) and demonstrated different abilities with each eye or poor ability which did not improve when the occluder was removed. Three of these failures also failed the miniature toy test (tables 24 and 25), two of them showing consistent deviation to one side and the third failing the cover test as well. A fourth failure also had unparallel extraocular movements. Two children passed all other tests but were so generally uncoordinated with and without occluder that they were considered worthy of follow-up on this basis alone.

Dominance

Passing and failing cannot be applied to these tests; children who had not established dominance were considered nontestable (tables 1, 2, and 11) rather than failures (tables 22 and 23). Those with mixed dominance might be considered "failures" but the evidence did not seem to warrant this.

Color

Of the 36 children considered testable (tables 1 and 2), there were 3 who obviously knew that colors existed and could name several colors correctly but consistently confused red and green. These children, all boys, were considered failures (tables 22 and 23) and probable examples of color blindness or achromatopsia. All three were testable and failed at least one other test (table 24), none of which depended upon color awareness.

Questionnaire

Of the 90 children for whom there were satisfactory questionnaires (table 2), a total of 66 could be considered failures on the basis of personal history, family history, prematurity or combinations of these factors (table 23). Of these 66 failures, 25 were generally nontestable, and particularly could not be tested with occluders on the visual acuity tests. Of the remaining 41 failures who were testable, there were 18 who failed other tests in addition and 23 failed only the questionnaire (table 24). Children who had suspicious histories and failed only one test, particularly those four who failed only the penlight following were recommended for followup on the basis that they might later develop clinically apparent inequality between their eyes.

VI. FOLLOWUP OF SUBOPTIMAL FINDINGS

Children recommended for followup

If all suboptimal or questionable findings on every test and questionnaire had been given the same consideration in formulating followup recommendations, all of the 94 children tested would have deserved followup. However, tests were weighted differently; those which could be failed, especially the visual acuity tests and particularly the miniature toy test were most important in deciding if followup was necessary. The other tests like OKN and color provided findings which were of concern in many cases, but the significance of these findings is still somewhat speculative. Most children who were severely negligent in areas other than visual acuity also failed the toy test and were therefore included among those recommended for followup.

Since one of the original objectives of this study had been to survey the W.C.C. children for amblyopia and since the recommendations were made on W.C.C. records, it seemed wise to limit this record entry to factual findings and to base the recommendation on whether there was low vision in one or both eyes. Children who were nontestable or failed the miniature toy test constitute most of the 54 children; children who passed the toy test were recommended for followup only if there seemed to be from history or another test, some imbalance between the eyes which might later produce a difference in visual acuity. The 40 children who received no recommendation seemed to have little likelihood of developing amblyopia.

The summaries for the records included a statement of pertinent history, acuity in both eyes, or left and right eye, a statement about testability with picture charts and direction-based tests a statement about eye preference, and a rating of performance. A sample summary of a case follows:

> Date of test. Vision Study.
>
> Visual acuity left—right eye with miniature toy test. Names pictures with unusual terms. Direction sense inadequate for test. Looks right esotropic on following light but shows no evidence of suppression on stereoscope. Dominance nearly established left eye and left hand. Fair spatial perception.
>
> Recommendation. Retest in 6 months to see if muscle imbalance may produce vision loss.

There were three types of recommendation given to a total of 54 children: (1) recommendation for immediate referral given to 3 children; (2) recommendation for followup in nursery school given to 2 children; and (3) recommendation for retest given to 49 children.

1. *Recommended for Immediate Referral*

Three children (two boys, one girl) were thought to have striking unilateral amblyopia and they were referred back to the W.C.C. for immediate referral to an eye doctor. Case histories follow; see table 24 for a summary of test and questionnaire findings and comparison to other children.

G.F., 42-month-old white male had shown slow development, particularly of language, and had looked "lazy-eyed" for several months. His mother was considering a visit to Massachusetts Eye and Ear Infirmary (M.E.E.I.). He did not talk at all during the test session but did seem interested in games and followed instructions well with the miniature toy test. Visual acuity in the right eye was much better than the left; there was readier acceptance of mask for occluding left eye. He could not perform tasks—ball, peg bench, and puzzle—with left eye alone and fair performance with the right alone was the same as that with both eyes. Cover test revealed left esotropia. Dominance was nearly established for left eye and right hand. Two months later he was seen at M.E.E.I. for a fourth visit and Mrs. F. was told to return in 5 months because he was nontestable; she had been given "E" cards to train him and found his comprehension of this limited. His speech retardation was studied at Children's Hospital Medical Center where he is being seen by the psychiatry department and attending the Sarah Fuller Foundation (for speech and hearing) Nursery School. This attendance has been interrupted by family problems; parents were separated and child was under Division of Child Guardianship for several months. Seven months after initial testing, at the M.E.E.I., the mother was told his vision was "good enough for a 4-year-old," and he was to return in 6 months.

C.G., 45-month-old Negro female had always been "clumsy" and "sloppy", had had periods of excessive blinking and frequently requested sunglasses, all of which the mother considered perversity. A 6-year-old brother failed the school vision test and has strabismus, an 8-year-old sister also failed the school vision test and wore glasses for 2 years because of "slow focus" and nearsightedness. This child was easily tested and showed good visual acuity with the right eye and very poor vision in the left eye with miniature toys. She had excellent ability at indicating directions. The left image was not reported on either red glass or stereoscope tests. Fair spatial perception was worsened when right eye was occluded. Dominance was established for right eye and right hand. An appointment was made for the child with the family's optometrist but, when the date arrived, "it seemed a shame to waste an afternoon out by taking that brat along," and mother went alone. Intervening pregnancy has further delayed this child's care. Seven months after the initial test, she was seen by the optometrist who advised the mother that vision in the child's left eye was weak and they should go to M.E.E.I. for treatment. Mother had hesitated to go because of the expense involved and thought she would go to City Hospital Eye Clinic instead, "in several weeks."

C.W., 54-month-old Negro male who appears to have partial albinism had always been slow in development, antisocial, and clumsy, held things close to his face, and frequently had bloodshot eyes. Testing environment was complicated by a younger sibling being tested and constant disparaging comments about this child from observing mother and grandmother. On the Stycar distant letter test, he had an acuity of 6/4 in the left eye and 6/18 in the right eye, and on the near letter test held the test card 6 inches from his right eye to see the small print (6 point) that he could see 12 inches away with the left eye. On cover test and penlight following, he showed right hyperphoria. Recommendation was for referral through W.C.C. One month later he had not been to W.C.C. and family was urged to go directly to an eye clinic. Three months later he was taken to City Hospital by his grandmother who decided while waiting in the pediatric clinic that what he really needed was a circumcision and this should be the order of business. "First things first," she said, and "I thought about having him circumcised long before I thought of getting his eyes examined." Nine months after the initial test, he had neither received eye care or been circumcized and the grandmother was waiting until after he had had his teeth extracted.

2. *Recommended for Followup in Nursery School*

Two children who did poorly on test 6, performance tasks, and were not recommended for retest based on visual acuity tests, seemed to have incoordination particularly inconsistent with their age and other abilities. There was no question of amblyopia, but it did not seem that without good coordination, vision could not be optimal. Nursery school was mentioned by both mothers and it was decided to follow these children there.

T.E., 41-month-old Negro male had an unremarkable history. Vision was equal with miniature toys. Spatial perception was poor. There was incompletely established left eye and right hand dominance. At nursery school he was described as awkward, slow, unenthusiastic.

D.O., 46-month-old white male had an unremarkable history. Vision was equal with miniature toys and with near letter test. Spatial perception was fair. Dominance was established for left eye and right hand. He was never enrolled at nursery school.

3. *Recommended for Retest*

Forty-nine children were recommended for retests either because of initial nontestability or failure not severe enough to warrant immediate referral. Nontestability was related to two factors: immaturity and adverse environmental conditions. Children recommended for retests and the primary reasons the initial test was unsuccessful are summarized in table 26 according to sex, race, and age.

The 12 children who were testable and recommended for retest with a question of developing amblyopia showed slight inequalities in the acuity of the two eyes, or had a history of occasional strabismus and a suggestive stereoscope cover test. These children were considered potentially amblyopic and particularly in need of followup. Two children who failed the toy and distant letter tests (table 24) were not recommended for retest because the inequality between their eyes was in the range of better-than-expected vision and did not represent significant loss of vision in one eye. Other findings on these children showed that they were using their eyes together and had excellent ability to coordinate visual and motor activities.

The 25 children who were considered nontestable because of immaturity included children who were completely nontestable, others who rejected occluders so that each eye could not be tested separately, and children

Table 26.—BASIS OF RECOMMENDATION FOR RETEST FOR 49 CHILDREN (According to Sex, Race, and Age)

Basis of Recommendation for retest	Total	Sex		Race		Age (months)																			
		M	F	N	W	31	32	33	34	35	36	37	38	39	40	41	42	43	44	45	46	47	49	53	54
Testable:																									
Developing amblyopia	12	9	3	5	7	----	----	1	1	----	2	1	1	----	1	1	----	1	1	1	----	----	1	----	----
Nontestable:																									
Immaturity	25	13	12	8	17	1	1	3	2	3	4	3	2	----	----	3	1	1	1	----	----	----	----	----	----
Environment	12	5	7	6	6	----	----	1	1	----	----	1	----	4	1	----	----	1	----	1	1	----	----	1	----

who were testable for the purposes of individual test tabulations but whose general demeanor indicated that their apparent failure was not real. Such failure seemed attributable primarily to immaturity, easy distractability, restlessness, short attention span. There were seven children who showed better ability with whatever eye was tested first and lower tolerance for occlusion of the second eye.

There were 12 children who could not be tested adequately because of the environmental factors, both physical factors, e.g. lighting and social factors, e.g. excessive interference from siblings or parents. Six of these might have been too immature to test even if the environment had been different. The other six were mainly hindered by environment alone. Adverse environmental factors did not deter all children, however. There were some cooperative and testable children who managed in the midst of as many as eight other interested children to attend to the tests.

Retests

Retests, performed about 6 months after initial testing, included two of the original tests: test of eye dominance with the cardboard in two hands, and the miniature toy acuity test. These were given as described above. Mothers were asked one question, "Has the child been well this winter?" These tests were chosen because the main reason for retesting was to detect additional children with amblyopia and a simple visual acuity test seemed the most expedient way. The relation between testability and dominance (table 21) was further investigated by the inclusion of an eye dominance test. The question concerning the child's health was asked in order to discern if there was some reason for continued nontestability.

Of the 49 children recommended for retest 37 were actually approached for retests. Eleven of the twelve children whose environment had seemed the major deterrent to testing were not approached at all for retests which were performed in the homes; one who had a strongly suggestive history was approached at

Table 27.—RETESTS OF 12 CHILDREN WITH POTENTIAL AMBLYOPIA (Findings According to Sex, Race, and Age)

Findings	Total	Sex		Race		Age (months, at retest)																			
		M	F	N	W	37	38	39	40	41	42	43	44	45	46	47	48	49	50	51	52	53	54	55	56
Not available	1	----	1	1	----	----	----	----	----	----	----	----	1	----	----	----	----	----	----	----	----	----	----	----	----
Nontestable	2	1	1	0	2	----	----	----	----	----	----	----	----	----	----	----	----	----	----	----	----	----	----	----	----
Testable, pass	7	6	1	4	3	----	----	----	----	----	1	----	1	----	1	1	1	1	----	1	----	----	----	----	----
Testable, fail*	2	2	0	0	2	----	----	----	----	----	1	----	----	----	----	----	----	----	----	----	----	----	----	----	1

*See text for follow-up.

Table 28.—RETESTS OF 25 IMMATURE AND INCOMPLETELY TESTABLE CHILDREN (According to Sex, Race, and Age)

Findings	Total	Sex		Race		Age (months)																			
		M	F	N	W	37	38	39	40	41	42	43	44	45	46	47	48	49	50	51	52	53	54	55	56
Not available	3	1	2	2	1				1			1									1				
Nontestable	12	5	7	3	9			1	3	2	1	2		1				1	1						
Testable, pass	9	6	3	3	6	1		1	1		2	4													
Testable, fail*	1	1			1												1								

*See text for follow-up.

nursery school, after phone contact with the mother, but the child completely refused to be tested. The 37 children approached for retests included the 12 who were potentially amblyopic (table 27) and the 25 who were incompletely testable because of immaturity (table 28).

Three children who received no recommendation on the basis of the first test were also retested to see if they remained testable and passing and to possibly enable an attempt at prognostigation about previous patterns of response. A 46-month-old boy who had relative amblyopia on the near letter test and had showed equal vision on the toy test (table 24) was retested; it was thought that he might in time develop amblyopia in the eye which was worse on the letter test. He continued to show equal vision on the toy test 6 months later. A second child had identified the same toys with each eye, but could not differentiate the small fork and spoon on the first test, and it was thought that she might show some myopia or know all the utensils when retested a few months later. However, she was not testable at all at the time of retest: A third child had equal and good vision on the toy test, but somewhat inconsistent ability on various performance tests; she received an overall performance rating of good (table 20) but her ability with both eyes open was not much better than with each eye alone and the possibility of alternating monocular fixation was considered. On retest, she continued to be testable and showed equal vision.

Thus a total of 40 children were approached for retests at home; 35 of these were retested at home and 1 was retested at nursery school. The four who were not retested included two who moved and two refusals. The children retested ranged in age from 37 to 56 months, with a median age of 43 months. There were 22 males, 14 females, 12 nonwhite and 24 white children retested.

Three children who had previously been testable were nontestable on retests for no apparent reason; they not only refused the mask occluders, but refused to take part in any way. Parents of the two who were considered potentially amblyopic on the first test were advised to have the children's eyes checked soon, but 4 months later had failed to do so. It is noteworthy that these were the only two children who had shown consistent deviation to one side on performance tests and for whom the diagnosis of eccentric fixation might be considered.

The 12 immature children who were nontestable on retest (table 28) had also been nontestable originally; 11 of these children acted exactly as they had 6 months previously and one cooperated completely except that he would not wear the occuluder or allow his mother to cover one eye. Several of these children might have been more testable if they had not recognized the tester and equipment and immediately recalled previous failure.

In this small sample, testability of boys improved more than the testability of girls; the 6 months seemed to make a greater difference at this age for the 12 males than for the 10 females retested because of previous immaturity (table 28). There was no correlation between recent illness and change in testability; some children had been sick all winter and became testable during that time while others who were well and making strides according to their mothers remained nontestable.

As in the original tests (table 21) there was a relationship between eye preference and testability (table 29). All of the testable children showed some eye preference, although two of them would not look through the cardboard until after the toy test. Of the 12 immature nontestable children 8 failed to show eye preference (table 29). The two potentially amblyopic nontestable children had had eye preference on initial testing and continued to show this, as did the one previously testable child not recommended for follow-up who was retested.

There were three additional referrals based on the retest failures (asterisks on tables 27 and 28). Referral slips were given to the families by the district nurse in an attempt to direct the children to appropriate care. Their original test failures can be identified in table 24.

Two of these who had seemed possibly amblyopic on first testing showed slight but definite decrease in vision in one eye.

R.M., 56-month-old white male (49 months on first test) had a history of intermittent right cross-eye for 1 year prior to original test but not appearing in the last few months. On initial testing, he seemed to be using both

Table 29.—EYE PREFERENCE AS AN INDICATION OF TESTABILITY

Supplement to Table 21, Based on Nontestable Children, Table 28 (According to Sex, Race, and Age)

	Total	Sex		Race		Age (months)																			
		M	F	N	W	37	38	39	40	41	42	43	44	45	46	47	48	49	50	51	52	53	54	55	56
No eye preference, nontestable	8	1	7	0	8	...	...	1	3	1	...	1	...	...	...	...	...	1	1	...	...	...	...	...	...
Eye preference, nontestable	4	4	0	3	1	...	...	...	...	1	1	1	...	1	...	...	...	...	...	...	...	...	...	...	...

eyes together and the only inequality was on the toy test where he was able to identify one more toy with the left than with the right eye. On retest, he identified all the toys with the right eye but none of the small utensils with the left, on repeated trials with good cooperation. He is the second oldest of five children, and 4 months after retest, the mother is still planning to take him to an eye clinic but has not had the time.

R.B., 42-month-old white male (36 months on first test) seemed to have a right squint on first testing, but right eye was slightly better than left on toy acuity test and he seemed to be using both eyes together. Parenthetically, OKN was faster moving right to left than left to right. On retest, he consistently missed all small utensils with right eye and recognized all toys with the left. He was referred to the Massachusetts Eye and Ear Infirmary where the mother was planning to take a 9-year-old sister who had failed the Massachusetts Vision Test. At the eye clinic they were asked to return for refraction, but the family was out when three revisits were made and there has been no follow-up.

The third failure had probably been misinterpreted on first testing as a case of immaturity rather than recognized as an amblyope.

P.G., 48-month-old white male (42 months on first test) had never received any well-child care, and his mother was particularly preoccupied and uninformative. He refused both occluders and was tested with both eyes and with his left, sighting or dominant eye, using the cardboard lorgnette. He would not use the lorgnette to occlude the left eye while sighting with his right. On retest, he accepted the masks, and was able to identify only two large toys at 2 feet with the right eye and all the toys at 10 feet with his left eye. Four months after retest, his mother was waiting for an older child to have some free time so he could take this child to Boston City Hospital Eye Clinic.

VII. DISCUSSION

Tests

Visual acuity—Stycar

Letter test. The poor response to this test in this study is contrary to previous experience in Britain.[29-31] An estimated 80 percent of children 36–48 months have been able to match four to five letters; here, only 44 percent could match a minimum of three letters. The literature on this test gives no breakdown of subjects according to age (no finer increment than one-half year) and cultural background. The test is based on those letters most often used in popular British culture, and it may be that children who have been exposed to these letters but not to exactly the same culture show poorer recognition. However, the test is also based upon child development studies which were done in this country; these Gesell norms[95] were established with a group of upper middle class culturally privileged children but are expected within limits to be universal. Children in this study who matched all five letters could not match any more than five consistently. Testability depended upon age and it was the older and generally more capable children who succeeded at this test. The findings are therefore not inconsistent with those of other authors, but neither are they identical.

Sheridan and Pugmire[96] claim that the normal visual acuity by 5 years of age should be 6/6 or 20/20 and that children who cannot read the 6/6 line are few in number and probably have some visual defect. Some optometrists contend that preschool children are normally hyperopic and the child who sees 20/20 before age 6 years is abnormal and has a good chance of becoming myopic at age 10–11 years; plus lenses are sometimes prescribed for near work in the early school grades.[12]

In this study, children who matched letters at a distance could see 6/6 and even 6/4.

The usual screening test in this country uses a referral level of 20/30 for 5-year-olds, 20/40 for 3- and 4-year-olds, and sometimes even 20/50 for 3-year-olds. The normal visual acuity of the preschool child, particularly the younger preschool child and the infant, is not definitely known. The levels used are chosen for operational facility. Although the 3-year-old may actually see as well as the 5- or 6-year-old, he has less familiarity with visual stimuli, less capacity to interpret what is presented to him from the visual clues he receives, and less ability to communicate his perception to the tester. By making the size of the target he must see larger, his chance of passing the test increases and the number of incorrect referrals decreases. However, if indeed the normal vision is 20/20, then 20/50 represents significant vision loss and some children who should be referred will not be. It would seem, from the limited evidence presented here, that 3-year-olds have better visual acuity than they are usually asked to exhibit on vision screening tests.

Vision might seem better if the targets and the means of communicating one's perception of the target were made more interesting. In subjective vision tests, partcularly tests for preschool children, motivation plays an important role in the results. The problem of matching letters is not so much more difficult than the problem of matching toys that the results should be so different (tables 2 and 3); but the interest of the children in these two problems and their motivation to perform tests based on these problems differed widely. Thus, the letters were not intrinsically interesting and there was little desire to see and match small letter targets. Distance and the mirror made this less appealing and the findings for the distance test were worse than for instruction in letter matching and the near test (tables 2 and 3). The mirror was too interesting in itself and distracting. The matching improved when a more appealing method of giving answers was introduced in the form of the Lotto game;[33] motivation to see the small letters increased when seeing meant that a penny could be used to cover a similar figure on the key card.

The near test was performed with ease by all children who passed the distant letter test. There is questionable significance to the one child who failed the near letter test and passed the toy test. This information does not contribute much to the controversy over the value of near vision tests, e.g. for detection of amblyopia in myopes,[26] or for detection of a cause of reading failure.[97] Whether or not these tests should be included in vision screening batteries is an unsolved question. The main advantage of the near test would seem to be the enhanced cooperation at close range. In the Stycar near letter test, the smallest print, 6 point, was easily read by all the children who passed the test, and they probably had sufficient accommodative ability to read much smaller print. However, here again the idea of making the target appealing enters. The miniature Osterberg chart was intriguing as a whole, but once the children recognized that it was the same as the large chart or named a few of the larger pictures, there was little interest in diligently naming pictures on the smaller lines. Thus the small picture chart was too small and the small letter chart could have been smaller. While the near vision tests for preschool children might be useful, e.g. for detection of amblyopia in a myopic child, they cannot, in their present form, replace distant vision tests. Twenty feet, even created by a mirror at 10 feet, is too great a distance for a 3-year old. Ten feet seems to be a comfortable distance, at least when the test is being given on familiar ground and the targets are interesting; presumably this is far enough to represent optical infinity.

Miniature toy test. The Stycar miniature toy test would seem to be an improvement over other currently used acuity tests for the 3-year old (table 2, fig. 3). This test is appealing, easy, and has the theoretical advantage, not shared by most acuity tests, of testing real vision, i.e. the sort that is useful and bears a resemblance to visual tasks a person performs in life. People do not have to discern the direction of E's at 20 feet, but they do have to spot toys across the room. It also has the theoretical disadvantage of being impossible to standardize accurately. The targets are such different shapes and textures that the test itself could never be administered exactly the same way from time to time. It would be impossible to calculate the visual angle subtended by each toy, a three-dimensional object which can appear from any number of aspects.

Thus some of the features which make this test attractive to young children are the very features to which ophthalmologists might object. If the test itself is not very accurate, how correct will the referrals be? Unfortunately, referrals based on this test have not yet received sufficient followup to begin to answer this question. If, however, children who cannot be tested otherwise, are testable with this test, it is a worthwhile procedure. If the number of children tested increases, the number of correct referrals as well as needless referrals increases.

This test was recommended for children 20–36 months old, but in this study it was popular with all the children (up to 54 months) and also with many older siblings and parents. Although its use may be relegated to the younger preschool child, it could probably also enhance the testability of a number of older children who are given more accurate tests.

The miniature toy test can be administered in under 10 minutes, in most cases is close to 4 minutes. Fewer toys could be used, but understanding the principle rather than making the toys match is the time-consuming aspect.

Occluder acceptance (table 4) is a definite problem which does not seem soluble by changing the shape of the occluder itself. The idea of covering the face and eyes is what seems to bother the children who reject occlusion, even by mother's hand. This characteristic behavior [98] is not usually overcome by using the lorgnette instead of the mask although the desire to peek through the lorgnette [25] occasionally allowed testing of one eye when the mask had been rejected. The children who did not flatly reject occlusion were reassured when mother or the examiner also wore a mask and when they were told they could remove it shortly.

Visual acuity—Naming pictures and toys

The most noteworthy finding which came to the foreground with these tests was the large number, almost 10 percent, of the children who did not speak at all and the 57 percent of testable children who did not speak well for their age. Slow and inadequate language development seems unusually prevalent in this population. It is impossible to state with any certainty whether these young children will later show more far-reaching language problems, e.g. reading disability or be among school dropouts for related reasons, but it is tempting to speculate along these lines. Such culturally underprivileged children and their families have not received the attention of the various professional groups studying specific dyslexia.[93-99]

The finding of such children would seem to be an important byproduct of vision screening with subjective tests. These children may be testable and pass, or nontestable if standard procedures are used; in such situations, they are not immediately referred. Yet, their problem may later involve vision, at least as written language. Perhaps they should be referred to a neurologist, or a speech and hearing clinic; they probably should not be ignored.

The nine children in this study who did not speak were followed. Five mothers had expressed concern about this; four seemed to expect speech retardation, usually because older children had had a similar pattern of development. Of the five who had concerned mothers, three boys received evaluation for this problem; two at Children's Hospital Medical Center (one, an amblyopia referral) and one at Boston Dispensary and Putnam Clinic Nursery, and two started to talk well soon after the vision test.

The picture tests were well liked, and there was no problem of inability to identify pictures when the corresponding toy was recognized. Having like toys helped children who could not talk communicate the fact that they could see the picture presented, and these tests might have better success generally if matching, as well as naming, was used as a means of communication.

Ability to name pictures definitely seems to increase with age, but there is overlap with other abilities like indicating directions (fig. 3). A child who can indicate directions may not yet speak well; most children who speak well can also indicate direction. A combination of these two tests probably does enhance testability in the younger 3-year-olds, but not as much as the combination of the miniature toy and direction tests, or perhaps miniature toy and OKN (table 18).

Visual acuity—Indicating directions

Despite relaxed criteria of testability (table 1) and the use of instructibility in the hand test as a base line, the ability of 3-year olds to indicate directions seems limited. It seems clear from the direction tests in this study that most 3-year-olds do not have direction sense developed to the point of testability, especially if direction based tests with more than two choices (up and down) are used. Testability may be increased by requiring two of four rather than three of four directions to be correctly indicated (fig. 2). There is some indication that 3-year-olds do not memorize patterns in a two-choice guessing game, and so the accuracy of the test might not be greatly impaired.[100]

The hand seems to be easier than the "E," but this is probably significant mainly for children around age 3, a transitional period when this ability to recognize directions is developing. Then the more concrete symbol of the hand is easier than the strange figure "E." For the (developmentally) older child, the difference is probably not significant, and for the younger child both the hand and the "E" are too difficult.

That the fourth year of life is the time when direction sense becomes testable has been demonstrated inadvertently by several preschool vision surveys.[45, 50, 101] Whenever a breakdown of results by age (in increments of months) is included, it is apparent that testability increases markedly after 42 months. In one study [50] testability increased from 25 to 75 percent.

In California now a new direction-based test,[101] the "Do-As-I-Do Clown" is being used. The child matches directions to the clown's hand as it changes its direction. The advantage over the Snellen E is a shortened testing time in children over 48 months. This tends to improve methods for the older child, but changes the trimmings alone and does not change the fact of developmental stages which preclude the younger child's testability.

A greater increase in testability is gained by the use of a conceptually different test like the minature toys. For instance, 37 of 66 (56 percent) children under 42 months and 21 of 25 (84 percent) children 43–47 months were testable with the toys compared to 1 of 8 (12.5 percent) children under 42 months and 5 of 10 (50 percent) children 43–47 months testable in the Berkeley preschool survey.[101]

While the direction tests, especially the "E" and the Landolt ring are theoretically the best vision tests available, they are not the best in practice, when young preschool children are the subjects.

Visual acuity—Eliciting OKN

The 3-year-olds studied often showed nystagmus when presented with a moving striped stimulus (tables 2 and 7). The combination of this and another acuity test like the toy test may be a way of improving testability of preschool children which seems self-limited on subjective tests alone (table 18). The fact that the design for a more refined OKN apparatus will have to include an obvious occluder and/or some binocular device (like the stereoscope) will tend to diminish the success of this test with 3-year-olds.

In the testing of even younger children, an objective test like OKN is the only standardized method now potentially available. Horizontal nystagmus which is easier to elicit and observe should be the basis of such a vision test. The contrast between the lines and spaces between the lines should be great, e.g. black and white since less contrast may produce nystagmus based on seeing every other line and the level of visual acuity may not be determinable.

Muscle balance

NPC and penlight following. NPC and penlight following did not add much information; positive findings here were difficult to reconcile with other findings.

Cover test. The cover test was the most useful of the muscle balance tests given, under the circumstances of this study; poor cooperation, inexperience and the fact that only a near test was given make the findings debatable. It was assumed that both corneal reflections should be centered at the same time, but this is a fallacious assumption for those children who do have some lack of parallelism which is within limits. The findings of this study indicate that 19 percent of testable children on the cover test show some deviation of one eye. This unusually high rate of strabismus may be attributable to misinterpretation of the test, but this may also mean that these children differ from expectations in this way. Gesell's dynamic retinoscopic studies [10] have shown that many 3-year-olds normally alternate fixation, and function monocularly at times. This apparent strabismus on cover test may then represent a developmental stage. Thirteen percent of a group of 3-year-olds screened by an orthoptist in Manchester, England [45] showed strabismus compared to 2 percent of school-age children. Is this possibly a finding which is normal at a certain age, and in most cases tends to resolve itself without symptoms and without amblyopia? The actual prevalence of strabismus at various preschool ages is not known and the prognosis for the development of amblyopia has to be determined.

In the group of 12 children retested because of potential amblyopia (table 27), 1 of the 2 testable failures had shown muscle imbalance on the cover test (table 24). The poorer eye on the retest in each case was the one which had seemed to turn in, although the opposite eye had tested slightly worse the first time.

Of the six referrals, four showed muscle imbalance on the cover test and one showed suppression of an image with the red glass and stereoscope (table 24). These findings were better than those based on the questionnaire: only 2 of the referrals had a history of strabismus and only 1 was a strong history; there were 13 other children with a positive history but no strabismus on examination.

Red glass test. The red glass test cannot be successfully used in a young preschool population of this type. Its dependence upon color and number makes most children nontestable.

Stereoscope. Stereoscopic devices seem not to have their optimal success at this age; 38 percent of the children were testable in this study with a hand stereoscope. The commercially produced vision tests, based on a Brewster stereoscope have many advantages over traditional vision tests done at 20 feet; these advantages include rapidity of administration, uniform lighting, the need for only one tester, and easy storage.[102, 103] However, older children seem to be intrigued by such machines more than these younger children were; they have been successful as school tests, but have not been adequately tried with preschool children. The disadvantage of a poor response outweighs any advantage the machine might have. Distance of 20 feet is simulated in these machines, but children in this study seem to respond as adversely to simulated distance (of the mirror on the Stycar letter test) as they do to actual distance. Even when a hand stereoscope is used to determine fusion suppression of an image, interpretation is difficult. The testable child of 3 years sometimes does not report what he sees in sufficient detail or omits details because they do not interest him, and the decision of whether this is real or apparent suppression is not easily made. Even adults who are known to have equal and normal binocular vision will report that they see something consistent with complete suppression of the image from one eye when the picture shown to that eye is rejected by the subject.[104, 105] The stereoscope is most useful when the subject reports a single fused image and can hold this image; then, the examiner knows the subject has stereoscopic vision. When the subject does not report a fused image, the examiner cannot be certain the subject does not usually function with stereoscopic vision.

This situation applies to other tests of stereopsis as well. For instance, the fly observed through Polaroid glasses appears three dimensional if there is stereopsis and two dimensional if there is not. If the subject responds dramatically to the fly, or pinches his wings away from the page he is assumed to be functioning binocularly; if he does not show a startled reaction or pinches the wings close to the page, he may or may not have stereopsis. This test and others like it are difficult to interpret with young preschool children who may not understand the instructions, may not have learned to be startled by flies, and may actually be monocular at times. People of all ages although they have binocular vision may express themselves, e.g. in their art work as if they perceived a very flat two-dimensional world; this cultural factor has to be considered when examining physiological phenomena.

Performance

These performance "tests" were more popular than any others with the children. They have limited use as means of detection of vision loss. However, in the otherwise nontestable child an estimation of visual ability may be made from watching activities like these and this may be the only available subjective test. Performance of the same task with and without occluders gives some idea of relative visual acuity and can be used to detect severe defects. This becomes a less refined version of tests for toddlers like the Candy Bead test [21-24] and Worth's Marble Balls.[19, 20] Very accurate performance tests, i.e. active games which are vision tests can probably never be devised.

Performance tests are most useful as a means of observing the child's coordination and the way he uses his eyes with the rest of his body in dealing with his environment. Children in this study were poorly coordinated compared to their peers who were used to establish Gesell's norms.[95] Thus the children who could do as well as Gesell's 36-month-olds had a mean age of 43 months (table 20), i.e. were 7 months later in their development; all of the other children were more than 7 months behind the expected normal. Thus all of the children technically failed this section. This represents a problem for these children. But is this a problem with which vision screening should be concerned? Is it the role of preschool vision screening to detect these children with any vision problems other than amblyopia? Any basis of referral other than poor acuity tends to increase the number of referrals and to detect problems which are not detected and not treated by most eye doctors.

The dilemma is reminiscent of the situation with the Betts Sensation and Perception Tests performed in schools in the 1930's. These tests were functional and the referral rate was about 85 percent, most considered unnecessary by the consultant opthalmologist.[102, 106]

If the goal of screening is limited to the detection of low vision, especially unilateral amblyopia, then many problems which are not such purely visual problems will be missed. Such a screening program detects children who do not have two good eyes; those who cannot be helped will probably suffer little as long as their one good eye remains intact. It is not correct to publicize such a program as a detector of visual handicaps which may later hinder the child's school work. In addition to or in conjunction with ophthalmological care, there are children who need training in perception, coordination, etc. "Visual training" is being done by some optometrists and receiving much publicity,[107] but the substantiation of this work is yet to come.[93]

Dominance

The findings on the sighting tests indicate that children start to demonstrate an eye preference during the fourth year. This preference seemed to be consistent for each child tested and retested. However, it is possible that actual establishment of eye dominance occurs later.[108] There is some change in laterality between age 3 and 4 years which one may observe in nursery schools. Most children in the younger class (3 years old) eat with both hands and use both almost interchangeably in play while in the older class (4 years old) most children eat with one hand keeping the other beneath the table and use one hand much more than the other in play. True handedness, again, may not be fully established until much later, but the preference is shown at this age. Some children show strong side preference even earlier, of course, e.g. the newborn with a strong tonic neck reflex.

The most interesting finding on the sighting tests is the high association of demonstration of eye preference with testability, particularly the acuity of each eye. Most children who had not developed eye preference rejected the occluder and most who were developing eye preference accepted the occluder (tables 21 and 29). Thus a rapid test of testability would be a simple sighting test, e.g. giving the child a cardboard tube to hold with both hands and asking him to look through it. Children who did not use an eye to sight after several moments would probably not be testable and there might be no need to proceed with instruction on the vision test and struggle with occluders. According to the findings in this study, 50 percent of children judged nontestable on the first attempt by the use of this sighting screening method will become testable in 6 months. A few testable children will be missed by this time-saving method; there were children who demonstrated no eye preference and were testable (table 21). The use of sighting as a prescreening test should therefore be limited to situations in which time is especially important.

There is no reason to state from the findings in this study that children with "mixed" dominance are any less achieving than those with "straight" dominance (table 12). The 18 recommendations for follow-up from the dominance testable, group included 14 children with "straight" dominance and 4 with "mixed" dominance; the reason for follow-up was some questionable finding rather than nontestability.

There was no striking difference in the occurrence of straight and mixed dominance in the total testable group between male and female, nonwhite and white children. However, 12 of the 18 who received follow-up recommendations were males, including all 4 with "mixed" dominance. Of the three children who were recommended for immediate referral, two showed "straight" dominance and the third was "mixed."

Color

Matching by colors is supposed to occur before matching of forms in development. However, in this study only 2 children matched by color on the miniature toy test and 80 matched by form. Ability to match and name colors probably develops later in children who are culturally underprivileged. Children who are taught colors at home usually learn to name colors in the preschool years. However, the child's background must be considered before any action is taken for inability to name colors. Harper[109] lists failure to learn colors by age 4 years as an indication for ophthalmological referral, but in a group similar to the one studied, this action would seem premature and produce many unnecessary referrals.

From the limited vantage point of this study, color did not seem to be an important contributing factor to the way children deal with their environment in the early preschool years unless specific color conditioning had taken place. This is not to say that color was not appealing to these young children; they do not, however, seem to be aware of colors as qualities of some objects shared by other objects regardless of the nature of the objects themselves.

Questionnaire

The questionnaire gave much information which was not directly useful either as preparation for testing or as data considered for followup recommendations. Some of this information sounded unreliable as it was related and was not therefore weighted too heavily. If the questionnaire had been filled in by parents rather than at an interview, this judgment could not have been made. The background information about the child did not seem to fit the child tested in many cases; children described as "pills" with a very short attention span were completely testable while others described as "smart" with long attention spans would not cooperate at all. The most important contribution of the questionnaire was its provision of an opportunity to talk with the mother about the child and get a feeling about her interest in and expectations for him. This very subjective finding might easily differ from another observer's and cannot be used as a fact to be collated with other findings.

The important facts on the questionnaire were the personal history of signs and symptoms possibly referable to eye disorders (table 14), family history of eye disorders (table 15), and predisposing factors to eye problems in the child's history (table 16). This high risk group of children are those most likely to have or develop visual difficulties and should be particularly checked by the pediatrician and perhaps periodically by an ophthalmologist as well. If every child with a suggestive history in one of these three categories was referred, the referral rate from the questionnaire alone would be quite high. When there is a strongly suggestive history, e.g. several siblings under treatment for strabismus, a questionnaire might be a sufficient screening device. However, many cases of visual problems, like amblyopia, are asymptomatic and some mothers are not particularly observant, factors which lead to underreferral; and only some children with a positive history have visual problems, a factor which leads to overreferral.

In this study, the questionnaire was not used by itself in considering who deserved followup. Children who were testable and passed were not followed even if they had positive histories. The questionnaire findings on the six referrals are illustrative of the problems a questionnaire presents. There were 4 children who had symptoms or signs; 2 had turned eyes and 2 were clumsy, sensitive to the sun, and blinked excessively; there were 15 other children with symptoms and signs who were not considered in need of referral. All 6 referrals had a positive family history but so did 51 other children who were not referred. None of the referrals had been premature. Obviously all questionnaire findings cannot be given equivalent consideration, and it is helpful to use this in conjunction with or as a supplement to vision tests.

Referrals

Referrals from this study of vision tests were all based on the finding of unequal vision in the two eyes, i.e. unilateral amblyopia. There has been no followthrough on referrals and it is therefore impossible to judge the validity of the tests used from results of professional examination. An ophthalmologist examining these children would detect abnormalties not demonstrated by these procedures, and some of these tests give cause for concern in children who would not be referred to an ophthalmologist.

Recommendations for referral were based on visual acuity because low vision should include refractive errors and amblyopia on the basis of refractive differences, muscular or other imbalance. Corroboration of low vision by the ophthalmologist and elucidation of the reason behind this can be expected from the clinical examination. There would not necessarily be any additional information about the child's ability to deal with the visual stimuli of his environment.

Perhaps it is the nontestable children, those with language problems, or those with poor coordination who deserve followup. Should the pediatrician choose these children as vision problems and send them to the ophthalmologist? What could the ophthalmologist do with them. Perhaps there is no discipline yet developed which can deal diagnostically and therapeutically with all developmental problems relating to vision; perhaps the problems themselves have yet to be clearly defined and recognized.

The finding of 6 probable cases of am-

Table 30.—RATE OF AMBLYOPIA IN VISION SCREENING SURVEYS

Bibliographic reference No.	Number of subjects	Sex	Age	Percent amblyopia	Percent amblyopes without apparent etiology (strabismus, trauma, etc.)
	94	M & F	2½–4 years	6. 4	33
110, 45	301	M & F	3 years	1. 7	none
111	245	M & F	1–4 years	1. 2, *1. 6	------------
112	1, 572	M & F	3–5 years	**. 6	------------
113	12, 000	M & F	School	2	------------
24	25, 000	M & F	School	. 6	------------
24	1, 200	M & F	School	1. 3	------------
114	10, 000	M & F	4–85 years	***5. 3	------------
115	60, 000	M	Army inductees	4. 9	29. 2
116	21, 446	M	17–44 years	****2. 4	20
117	190, 012	M	18–36 years	5. 5	23. 8

*Two separate methods used.
**Based on actual cases of amblyopia among followed referrals.
***Population of successive patients at eye clinic unlike other surveys.
****Amblyopia defined as 20/70 or less unlike other surveys (less than 20/40).

blyopia in 94 children tested seems to be a large number. Table 30 compares the rates of amblyopia found in different types of vision surveys. Although an effort has been made to make the basis of these rates comparable, this has not been entirely possible because of differences in the surveys themselves and in reports about them. The definition of amblyopia in almost all studies was corrected vision of less than 20/40. In previous preschool and school surveys,[24, 45, 110-113] which list amblyopia, the rate varied from 0.6–2 percent; in the small sample reported here the rate was 6.4 percent. In a survey of consecutive ophthalmic patients,[114] the rate is higher as might be anticipated; children under 10 years had a higher rate of amblyopia (7 percent) than older patients did. The often quoted rates of amblyopia,[115-117] based upon army induction physical examinations, are higher than those for younger groups of males and females. One reason is that traumatic amblyopia accounts for almost one-third of these cases. It is possible too that the rate of amblyopia increases with age.

At least two of the six possible amblyopes were idiopathic; this agrees with other larger studies in which 20–30 percent of amblyopes had no apparent etiology on examination or history (table 30). In this group of six, only one had definite strabismus by history and another had a suggestive history, two others showed slight muscle imbalance on testing but had no such history.

These children are culturally deprived, and it is interesting to speculate about the possible role of sensory deprivation in the etiology of amblyopia. Can it be that when there is no reason to develop optimal binocular vision, it does not develop? Certainly development of vision after birth depends upon stimulation of the visual apparatus; just how stimulated does it need to be? Numerous infants in these large families are seen lying in dark rooms in cribs which face blank walls and ceilings with bottles propped in their mouths. The vision of the neglected child is said to develop prematurely; these children are seen under 3 months of age with little general physical activity and much eyeing of the environment.[18] This is perhaps a crucial time for the development of good vision, and the lack of response by the environment to the child's looking may possibly be related to loss of vision. This hypothesis can only be tested by parallel observations of infants and actual visual tests. The fate of such children can only be known by following them for many years.

It is interesting that in this particular group of referrals there were five boys and one girl, two nonwhite and four white children. Although the sample is small these findings seem consistent with other impressions. Girls are valued more than boys in this population, and may receive more of the necessary attention as infants. There is some evidence to indicate that Negroes have better vision than members of the white race.[119]

VIII. CONCLUSIONS AND RECOMMENDATIONS

Possible program for immediate use

Age of children to be screened

Children from 30 months on can be screened even though about 50 percent of the younger subjects might be nontestable. It is better to start early not only because early detection permits more effective treatment, but also because it seems to take so long for referrals to seek professional attention.

The recommended tests can be used effectively with children less than 3 years old and so have the decided advantage over more conventional methods of increasing the yield of positive early findings.

Tests

In order to save time and test only those children who will probably accept the occluder, a ***sighting test*** can be done, then only proceed with those children who show some eye preference.

The ***miniature toy test,*** which is appealing to the children and makes fewer demands on their abilities to speak and coordinate, should be used. Although less accurate than other available tests, this test does enable early detection of low vision in one or both eyes, and gives an indication of the child's ability to use his eyes in a way which is important to his normal development.

Place

Home. Testing in the home seems to have decided advantages over testing in the WCC. Many more children can be tested through home visits than in the WCC. Although some children who at least partially were nontestable for reasons pertaining to the home, there are equally adverse environmental factors at a WCC, e.g., other children, noise, many new people, associations with previous painful visits. Mothers are more often helpful than meddlesome, and being near one's own mother, refrigerator, and toilet are very important aids to cooperation.

WCC. The major advantage to testing at the WCC is that it takes less time than home testing where the need for excessive visiting is time consuming. Children can be tested at routine visits, but many preschool children are not brought in for checkups. Physical examinations for nursery school entrance should include a vision test.

Nursery school. It is feasible to take a vision test, particularly such a simple one, to a nursery school. This is a captive preschool population and vision testing is part of a school's general health supervision.

Tester. It would be possible for the district nurse to do vision screening. The fact that the nurse is familiar to the child would probably tend to outweigh the adverse association she might have in some children's minds. The main quality necessary would be the ability to approach the test as a game with a sense of fun and play. Any youthful nurse who enjoys working in a children's clinic would be capable at this.

It is generally considered unwise to have professional people perform vision screening because of the false sense of security parents may get knowing that a doctor tested their child's eyes but not realizing that the test was not a professional examination. Teachers and nurses frequently do vision screening, and doctors should test children's vision in their offices. Volunteers or specially trained lay technicians are preferred for large scale screening programs.

Major problems of preschool vision screening programs

Tests

The tests available for screening preschool vision need to be improved and perhaps changed fundamentally. The best techniques and screening tests available do not always detect those children in need of special attention. There is no good data on the number of children missed by screening programs, and there has been more attention paid to eliminating overreferrals than to preventing underrefals. Part of the problem is that not all eye doctors agree upon what constitutes a correct referral.

Even if some available screening test did correlate well with the professional examination, these screening procedures are limited by the children themselves. Under optimal circumstances, there will be a certain percentage of nontestable children. These nontestable children may include some with vision problems.

Follow-up

There is a major practical problem of getting children who fail screening tests to have professional consultation with necessary diagnosis and treatment. A screening program is worthless if there is no followup. Part of the solution to this problem will involve widespread publicity about preschool vision problems and the need for early eye care. Parents who are thus informed may be more willing to make an effort to seek appropriate attention. The more complex aspect to solving this followup problem is part of the larger problem—why do parents seek and reject medical care from various sources—but this is not in the domain of the present investigation.

Areas for further investigation

Objective vision tests

The development of an effective objective vision test which could be used effectively with preschool children and infants would answer many questions. It would permit even earlier detection of low vision, perhaps in the first year of life. It would aid in defining what is normal vision—something which is not really known for young children. It would decrease the number of nontestable children because it would require minimal cooperation from the child. It would enable children who are deaf or retarded to be tested and thus better separate the problem of communicating what is seen from the fact of having seen it.

Normal visual development

In order to interpret the findings of a screening test or professional examination at a single stage of development, it helps to know what normally precedes and what might be expected to follow this stage. If some large group of children could be followed from early infancy with periodic vision tests which were widely approved, then it would be possible to learn what is normal, what is unusual and transitory, what is abnormal and permanent. Visual development should not be the concern of one professional group alone (which has been proposed);[120] this is an area which would profit from a multidisciplinary approach.

Several current longitudinal studies might be used as structures within which to study normal visual development and the prevalence and prognosis of various visual abnormalities.

a. *Harvard Longitudinal Studies of Child Health and Development, Harvard School of Public Health:*

Children, who were followed from birth to maturity, received a visual acuity during the preschool years, and received the Massachusetts Vision Test periodically from age 6 to 18 years. In addition, physical examination notes include references to signs of eye disorder. This information has not yet been tabulated, but some patterns of visual development are potentially discernible in it.

b. *Child Research Council, Denver, Colorado:*

The Child Research Council, another longitudinal study of child growth and development, included vision screening tests but discontinued them because they were found to be inadequately accurate. Again this was a well-studied group of children and visual findings might have been related to numerous other factors.

c. *Maternal Infant Study, Collaborative Research, Perinatal Research Branch, National Institute of Neurological Disease and Blindness:*

This is a nationwide program which was started more recently than the two previously mentioned. Here is an opportunity then to follow children from a very young age. Unfortunately, at present, there is no formal vision test included in the protocols.

Current preschool screening programs

The Brookline Health Department is an example of an ongoing vision survey of several thousand preschool children. It includes ophthalmological examinations of children referred from screening, and could serve as a basis for a study of diagnosis, treatment, and prognosis of preschool vision problems.

Only after the expected development is known can the effect of various treatments be evaluated. There should be long term followup of cases treated now, but determination of prognosis for future cases should include consideration of normal growth and development.

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